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ABSTRACT

The executive summary is the first section of this final report of the evaluation of the ATS-1 medical communication system in Alaska. The second section introduces the background of these studies and the sociogeographic setting and health situation of the Alaska natives. The third section presents the main research findings about both the aides-to-doctor and doctor-to-doctor exchanges, about use of the system for medical education, and about its social impact on Bush Alaska. A fourth section is devoted to a cost analysis of alternative systems and recommendations. The attachments (charts, tables, data gathering instruments, etc.) comprise a fifth section. (WCM)

HEALTH CARE AND SATELLITE RADIO COMMUNICATION IN VILLAGE ALASKA

Final Report of the ATS-1 Biomedical Satellite Experiment Evaluation

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a report of the
INSTITUTE FOR COMMUNICATION RESEARCH
STANFORD UNIVERSITY

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HEALTH CARE AND SATELLITE RADIO COMMUNICATION IN VILLAGE ALASKA

Final Report of the ATS-1 Biomedical Satellite Experiment Evaluation

By Osvaldo Kreimer with the collaboration of
Heather Hudson and Dennis Foote, and including
a Course Evaluation by Virginia Hunn Fowkes
and an Evaluation of Future Communication Systems
by Bruce Lusignan and Michael Sites

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June 1974

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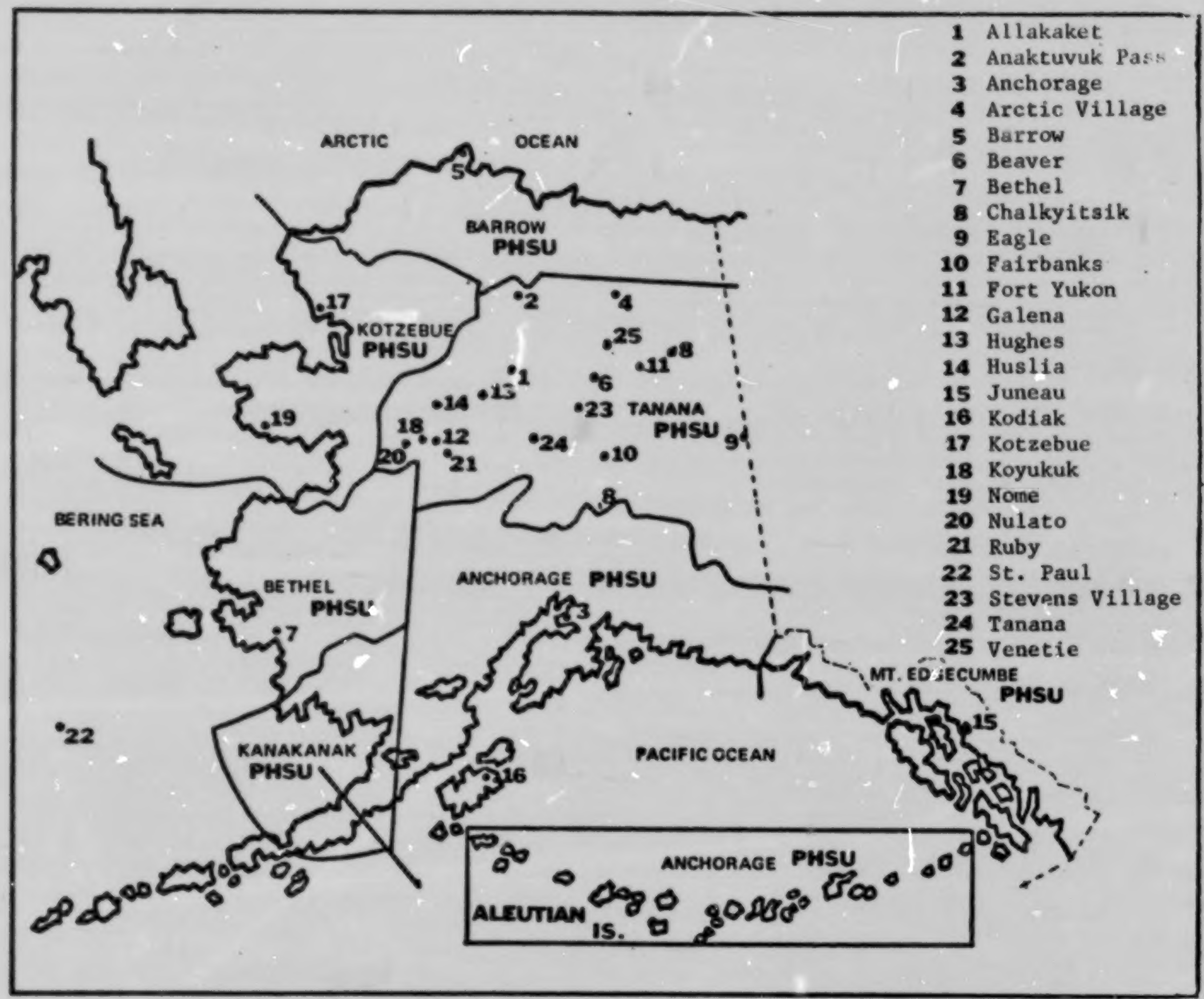
and
THE LISTER HILL NATIONAL CENTER FOR BIOMEDICAL COMMUNICATION

ALASKA LOCATIONS WITH ATS-1 GROUND STATIONS


1 Allakaket
2 Anaktuvuk Pass
3 Anchorage
4 Arctic Village
5 Barrow
6 Beaver
7 Bethel
8 Chalkyitsik
9 Eagle
10 Fairbanks
11 Fort Yukon
12 Galena
13 Hughes
14 Huslia
15 Juneau
16 Kodiak
17 Kotzebue
18 Koyukuk
19 Nome
20 Nulato
21 Ruby
22 St. Paul
23 Stevens Village
24 Tanana
25 Venetie
ARCTIC
OCEAN
BARROW PHSU
KOTZEBUE PHSU
TANANA PHSU
BERING SEA
BETHEL PHSU
ANCHORAGE PHSU
MT. EDGECUMBE PHSU
KANAKANAK PHSU
PACIFIC OCEAN
ANCHORAGE PHSU
ALEUTIAN IS.

PHSU = Public Health Service Unit

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EXECUTIVE SUMMARY

This executive summary is the first section of the final report of the evaluation of the ATS-1 medical communication system in Alaska performed by a Stanford University team. The second section (Chapters I to III) introduces the background of these studies and the sociogeographic setting and health situation of the Alaska natives. The third section (Chapters IV to X) presents the main research findings about both the aides-to-doctor and doctor-to-doctor exchanges, about use of the system for medical education, and about its social impact on Bush Alaska. A fourth section (Chapter XI to XII) is devoted to a cost analysis of alternative systems and recommendations. The attachments (charts, tables, data gathering instruments, etc.) comprise a fifth section.

Social Geography (See Chapter II):

Alaska has 16 percent of the total area of the U. S. but only 0.15 percent of the population. Of the total population (about 300,000) 20 percent (about 60,000) are natives (Eskimo, Indian, or Aleut). Their socioeconomic development has been strongly influenced by their physical environment: the severe cold, the frozen subsoil (permafrost), and the light cycle of summer midnight sun and winter darkness. (Ch. II.A.1) The natural food resources have been reduced by ecological changes, and most food supply is imported. (Ch. II.A.1) The cost of living and doing business is higher in Alaska than in "the lower 48." (Ch. II.A.2)

Alaska may be considered as two distinct entities: the urbanized areas (Anchorage, Fairbanks, Juneau and connecting lands) which are predominately white, and the rest of the territory, Bush Alaska, which is predominantly native. A century ago the native population was several times larger than it is today. (Ch. II.A.2)

The passage from a well-knit social organization with economic self-sufficiency and strong religious and cultural bonds, to a dependent economy, supported mainly by outside resources (military, welfare, education and health care funds) has caused an imbalance which is reflected in the sanitation and health conditions. The influx of machinery and people caused by the discovery of gas, oil, and minerals has increased that imbalance. Now the Land Claims settlement has provided a financial base to native people. Increases in personal income, immigrant population, and state government revenues are also expected from the exploitation of gas and oil.

Migration to the cities and disruption of the life in the villages has been the main consequence of the imbalance of the cultural exchange. New trends are appearing, both in the decrease in the rate of migration away from the villages and in the increase in the participation of the natives in their own government (Local and Regional Councils and Regional Corporations).

Transportation: Modern ground transportation is minimal. Except for a few villages, access is possible only by air, or seasonally by boat or snowmobile. (Ch. II.B.1)

Communication: 102 of the 180 native villages (population 25 to 1000) have no reliable telephone service; most of these rely on high frequency two-way radio. Two-thirds of all villages have no access to television, either live or taped. (Ch. II.B.2)

Health Situation in Village Alaska (See Chapter III): In the early 1950's Alaska natives were the victims of sickness, crippling conditions, and premature deaths at a rate far in excess of the rest of North America. The main problems were tuberculosis, maternal and child health, mental health, environmental and dental health. An inadequate health care system existed. By 1972 tuberculosis was under reasonable control and deaths from infectious diseases and infant mortality were reduced to near the average U. S. level. On the other hand, new problems have arisen, related to sociobehavioral circumstances: increased rates of death from alcoholism, suicides and homicides, and the growing importance of the number of admissions to hospitals caused by accidents, psychological disorders and abortions. Since the 1950's there has been a dramatic reduction in infectious diseases, but this improvement has been in part erased by an increase in socioenvironmental related problems and mental health diseases. (Ch. III.A)

Hospitalization trends: Between 1960 and 1972 there was an increase in the number of outpatient visits by natives but a stable rate for inpatients. The sharp reduction achieved in the average length of stay is considered an important advance. Main causes of hospitalizations were accidents, delivery, otitis media, and psychological disorders. (Ch. III.B)

Vital trends: Both birth and death rates have decreased in the past ten years. The birth rate of 3.2 percent in 1971 was 1.8 times the U. S. rate. Accidents are the leading cause of death among Alaska natives. Life expectancy at birth for the Alaska native born during 1959-1961 was 60.4 years, compared to the U. S. average of 69.7 years. (Ch. III.C)

High priority health problems: It is harder to confront these new problems than the strictly "medical" diseases. Mental disorders, alcoholism, drug use, homicides and suicides, venereal diseases, and otitis media are considered priorities by the AANHS, as well as environmental problems such as inadequate water supply, sanitation, and housing. (Ch. III.D)

Delivery System Organization: Multiple agencies and services plus the private sector provide health care. The Alaska Area Native Health Service (AANHS) which is part of the Indian Health Service is the main health care provider. It is supplemented or overlapped by: Medicare, Medicaid, the Alaska State Department of Health, the Office of Economic Opportunity, and the local autonomous health bodies at the borough level. Coordination problems are reported. (Ch. III.E) Native organizations are increasing their direct participation in the organization of the health care. The Alaska health delivery system may be compared with the system used by the Canadian Government, in which most remote native communities in the Canadian North are provided with a resident nurse and a nursing station which consists of a clinic, a few beds, and living quarters. Dr. Sixten S. R. Haraldson of the World Health Organization notes that Alaska spends about $700 on health care per Eskimo per year to cover all health costs, whereas Canada spends $740 to cover 60 percent of costs. "Canada seems to be spending more and getting less." He feels that using trained native health aides is the cheapest way to raise the standard of service in remote areas. (Haraldson, 1973b) Other health care professionals point out that the Alaska system is fragmented while the Canadian one is unified and better planned.

The ATS-1 Experiment--Background and Purposes (See Chapter IV):

During the summer of 1971, ground stations were installed at 26 communities in Alaska for twoway audio communication via the NASA ATS-1 experimental satellite. Nine of these stations were located in villages in the Tanana Service Unit which are served by native health aides. Other ground stations in the Unit were installed at the Tanana hospital and Fort Yukon where there is a nurse. Ground stations were also located at the Alaska Native Medical Center (ANMC) in Anchorage and in 13 other communities, most of which had doctors. The Alaska control station (Minitrack) is at the University of Alaska in College, near Fairbanks. (Ch. IV.A)

The primary use of the ATS-1 network has been for a daily doctor call between the doctor at Tanana and the remote health aides in the Tanana Service Unit. In 1973, six ground stations were moved from other sites where they had received little use to other villages in the Tanana Service Unit. (See Attachment IV.1)

Technical Evaluation of Satellite System Performance (See Chapter V):

Medical communication: Statistics were gathered for the year before and the two years after satellite use began both for the villages where satellite radio was installed and for a control group of villages with HF radio communication only. (Ch. V.A) In the "satellite villages" there was an increase of about 500 percent in the number of contacts completed and 400 percent in the number of health aide-to-doctor consultations about patients. Both figures are statistically significant. (Ch. V.D; Ch. VI.A)

One Typical Year of Doctor Call--1973 (See Chapter V):

The central figures for the system performance for 1973, a year in which the satellite system was already a fact of life for the doctors and participating villages are as follows:

Contacts completed: A doctor at Tanana attempted to contact the health aide at each village every day. For the average village, contact was made on 86 percent of the days. (Ch. V.G.2.a.)

The quality of the signal: For signal strength, University of Alaska monitors rated 84 percent of the 3,225 transmissions analyzed in the top category on a five-point scale. 14 percent were placed in the second highest category. For intelligibility, 62 percent were rated in the top category and 33 percent in the second on a five-point scale. (Ch. V.G.2.d)

Health Aide-to-Doctor Content (See Chapter VI.A):
The analysis of the exchanges during a full typical year of operation (1973) shows the following results.

Positive traffic:
In 67 percent of the possible contacts there were patient consultations and/or administrative matters to exchange. Thus in about two out of three days the average health aide had medical content to discuss. (Ch. V.G.2.b)

Patient-consultations: Sampling one health aide's records suggests that radio consultation is sought in two- thirds of the cases seen by the health aide. In 1973 the health aides in the 13 villages made about 3,000 radio consultations, which amounts to 2.0 radio consultations per person annually, or around 10.6 radio consultations per average family. (Ch. V.A.2.b) Winter and summer months have a higher number of patient consultations than spring and fall months. (Ch. VI.A.2.c)

Administrative matters: Each village discusses an average of 281 items per year (supplies, drug questions, inquiries about transportation and whereabouts of traveling medical personnel). (Ch. VI.A.2.d)

Time elapsed: The average village contact takes 4.3 minutes, an average of about nine minutes per person annually. 72 percent of the time was used for patient consultations and 27 percent for administrative matters. The average patient consultation requires three minutes and each administrative matter, one minute. Weekend contacts take about half of the time of the weekday ones. (Ch. VI.A.2.e)

The patients: Radio encounters refer to native patients of all ages. 22 percent of the cases concern children less than four years old, reflecting the high infant morbidity. (Ch. VI.A.4.c)

The diagnoses: The most frequent diagnoses were respiratory diseases, ill-defined symptoms, skin difficulties, ear problems and accidents. (Ch. VI.A.4.d) Only one-half of one percent were considered by the doctor to be very severe and complex. Two-thirds of them were considered in the middle category of "evaluation of a minor symptomatic problem with some risk of complication." Conditions involving the ear, circulatory system, accidents and genitourinary were rated as more severe than other conditions. (Ch. VI.A.4.e)

Management plan: In half of the cases the doctor believed that the health aide had planned, or could have planned correctly using his or her own judgment. Of the remaining cases, 20 percent required minor changes and 30 percent major changes. The best performance in this respect among the health aides was very close to the average rate obtained by the two registered nurses over the same system. (Ch. VI.A.4.f)

Predicted effects on the outcome: Definite and marked effects of the radio consultation on the outcome were predicted for more than 75 percent of each of the four highest categories of severity. (Ch. VI.A.4.g) These data require external validation due to the subjective factors involved. For internal reliability, see Chapter VI.A.4.b.

Travel authorizations: No clear relation between improved communication and "number of travel authorizations" was established. (Ch. VI.A.5)

Emergency calls: This feature of the system has shown its value and reliability where immediate communication was necessary either for urgent advice or a travel request. During 1973 there were 45 emergency calls, some involving more than one patient. (Ch. VI.A.3)

The Health Aides (See Chapter VI.B):

A typical health aide equipped with a satellite radio makes 309 contacts per year, including 250 patient consultations and 281 administrative matters. (Ch. VI.B.2) In an average month, with normally 20 patient radio consultations, fourteen refer to acute problems, four to acute follow-ups, and two to chronic management. Meanwhile the health aides at the non-satellite villages in the region consult by HF radio on less than two cases in an average month.

In three out of four cases, one radio consultation was enough to handle the case. In the other fourth, follow-up discussions were required. Otitis media, respiratory and dermatological problems were the conditions in which the health aide relied more on the doctor-consultation. On the other hand, with gastro-intestinal problems for instance, management was accomplished more independently. They also consulted more often about therapies involving antimicrobials, antibiotics and sedatives than about analgesics, antihistamines, and topicals.

The response of the health aides at the satellite villages, in contrast to those at villages supplied with HF radio, show that in the former there was no difficulty at any time understanding the instructions, and that it was more frequently possible to consult with the doctor before beginning treatment. Frequent communication with the doctor seemed to increase the health aides' ability to persuade the patients to follow their advice.

Health Aide Education via Satellite (See Chapter VII):

The opportunity offered by the satellite to listen to exchanges between other health aides and the doctor appears to be very important both for morale and for continued learning. The learning results suggest that the health aides with the chance to listen to medical traffic daily had a higher learning than aides in non-satellite villages for the first few months, but quickly reached a plateau after which incremental learning was slight. (Ch. VII.C)

Effects on Hospitalization Rates (See Chapter VI.C):

The trend before and after satellite radio installation shows no significant change, and shows stability in the number of patients admitted to the IHS hospitals from satellite villages. (Ch. VI.C.3) However, while the figures for the satellite villages remain stable, the number of patients hospitalized in native facilities from the non-satellite groups of villages dropped 42 percent from FY 1972 to FY 1973. An hypothesis is suggested: many patients in non-satellite villages could have switched to Medicare-Medicaid supported private services, an option introduced to the natives in 1972. It may be that improved telecommunication has resulted in higher acceptability of the PHS system and preference for it, when the choice of private services is available on an equal-cost (or no-cost) basis. Some alternative causal hypotheses were discarded.

The data for effects on the average length of stay at the hospital show overall superior trends for the satellite villages at each hospital. In the Tanana Hospital, where the less complex cases are treated, the average length of stay has increased in the four-year period between 1970 and 1973 (pre- and post-satellite). However, the increase was smaller for patients from satellite villages. At the ANMC, where the more complex cases are treated, the average length of stay has been reduced. Here the reduction was bigger for patients from satellite villages. In both cases the average length of stay is lower for satellite villages than for non-satellite ones.

Conclusions (See Chapter VI.D):

Additional data and analyses now make us conclude that health care in general has improved as a result of satellite radio communication. Indicators of improvement in professionalism and supervision, efficacy in emergency cases, inferred effect on outcomes, consumer acceptance, and adherence to the system have been shown through the analyses.

Doctor-to-Doctor Consultation (See Chapter IX):

Data about satellite radio consultation between the remote doctor at the Pribilof Islands and his specialist colleagues at the Anchorage Native Medical Center show that:

-The communication link was used on two-thirds of the days in the period under analysis. (Ch. VIII.C.1)

-In an average month there were six patient consultations and about fifty administrative exchanges, using an average of eight minutes per day of satellite time. (Ch. VIII.C.1)

-The average time elapsed in a patient consultation was six minutes, and three minutes for each administrative matter. (Ch. VIII.C.1)

-The annual rate of consultation is about 130 per thousand population.

-Transfer of the patient and/or change of treatment were the typical results of the consultation. (Ch. VIII.C.5)

-In the remote doctor's opinion, in most cases neither facsimile, ECG, nor audio-visual transmission would have materially improved the consultation. In 20 percent of the instances, however, the consultant considered the latter feature would have been valuable. (Ch. VIII.C.5)

-Most of the consultations referred to moderately severe problems. They were considered necessary but not pressing enough to make a delay of a few days to one week in the consultation result in predicted significant deterioration. (Ch. VIII.C.2)

Evaluation of Nurse Education (See Chapter IX):

A three-month course for nurses on coronary care was held once per week over ATS-1. The results were compared with results of classroom courses with similar goals, curriculum, and type of students taught at the Bellevue Community College in Washington. Difference scores for well standardized pre- and post-tests show that the satellite group at Alaska performed similarly to the classroom groups from Bellevue on both pre- and post-tests. An approximate 20 percent rate of improvement is noted. The students found the course content and material valuable, but most indicated that there were some difficulties with the radio transmission. These difficulties did not affect performance on tests of knowledge of the subject matter. The nurses indicated interest in additional courses.

Social Impact of Reliable Communication for Bush Alaska (See Chapter X):

Several social effects have been detected:

Family-patient contact: The satellite enables families in the villages to get news about friends and relatives at the hospital. Previously, getting news was often very difficult. (Ch. X.A)

Access: It was found to be important to have the radio transceiver located in the health aide's home. This decreases the physical and sociopsychological barriers to reaching the transceiver, increasing the number of contacts. Increased self-confidence was expressed by the health aides using improved telecommunications. It was also noted that patients felt reassured knowing that their treatment was checked with doctors.

Evaluating Future Communication Systems (See Chapter XI):

Future systems to provide health communications services to Alaskan villages were assessed. A computer optimization program identified a small station configuration (10-foot diameter antenna) as least costly for Alaskan rural voice communications. As the health delivery system will need only part of the capacity, that cost can be shared with other agencies and with paid telephone services. An analysis of RCA's plans for Alaska telecommunications is included.

Recommendations (See Chapter XII):

Several recommendations are made for improving health care organization and delivery, and for further research.

CHAPTER I

GENERAL INTRODUCTION

I.A. BACKGROUND

The native villages in Alaska have their primary health care delivered by health aides who are fellow villagers, backed by Public Health Service physicians at the regional hospitals. These remote communities, in most cases without any ground transportation, must rely upon telecommunication for medical support (consultations, emergencies, ordering supplies, and patient transfer requests). Most rely on high frequency two-way radios. However, auroral interference in the short wave bands makes HF communication unreliable.

As we will see later, life in the Alaskan villages has been subject to severe strains in recent years. To the known ecological challenges of the Arctic life, a cultural upheaval has been added. After World War II renewed interest in Alaska poured new people, goods, and institutions from the lower 48 states into the territory. With them the villages received new or improved services, especially in education and health care. This general change, added to by the discovery and exploitation of gas, oil, and minerals, threatened the basis of this delicate rural society, creating migratory trends to the cities, bringing in a massive influx of people and machinery, presenting to all generations conflicting values and life styles, and increasing the symptoms of maladjustment. On the other hand, the Natives reacted positively, organizing themselves to better defend their rights and take control over the institutions related to their lives.

Year-round jobs in most villages are few. More persons are unemployed or are seasonally employed than have permanent jobs.

> "Typically the opportunities are limited to positions such as school maintenance man, postmaster, airline station agent, village store manager, and possibly school cook or teacher aide. In these places, other adults gain income through the sale of furs, fish, or arts and crafts; find seasonal employment away from the villages as firefighters, cannery workers, or construction laborers; depend on welfare payments, make their National Guard income stretch mightily; or as is usually the case, (1) provide for the bulk of their food supply by fishing, hunting, trapping, and other activities of food gathering; and (2) rely upon a combination of means to obtain the cash needed for fuel, some food staples, and for tools and supplies necessary to the harvest of fish and wildlife. (Alaska Natives and the Land, 1968)"

The villages are places of contrast. Airplanes are used by people who fish for subsistence; satellite radio transceivers are placed in houses where the heating comes from metal barrels transformed into fireplaces. Their culture faces a pressing dilemma: either these contrasts will be absorbed in a synthesis of the traditional and the modern and oriented to the full development of the potentialities of the Arctic people, or it will be the source of conflicts that can end the originality and values of their distinctive civilization.

In this sense, it is of basic importance to supply the necessary social services to the population to achieve their primary goals (e.g. improving the health status of the Natives) without side effects that will increase the dependency of the community.

The people need to communicate with other villages and cities, and have the right to decide what communication they would like to be exposed to. However, a concrete dependency on communication coming from the outside can introduce models and patterns of consumption that are unrelated to their village development. In the case of health care, this dilemma seems quite clear. On the one hand, the Natives need and want to profit from modern medicine and medical institutions. On the other hand, the geographical configuration of the villages allows neither the installation of fully equipped institutions in all sites nor the introduction of medical personnel alien to the culture.

I.E. ORGANIZATION OF THIS REPORT

This report has been organized in five sections: first, an executive summary that synthesizes the main findings; second, an introductory section that includes this chapter and an overview of the Alaska sociogeographic setting and the health situation of the Natives (Ch. I-III); third, presentation of the main research findings (Ch. IV-XI); and fourth, a set of recommendations based on these findings and other relevant research and experiences. A fifth section includes the attachments.

Other major reports and articles produced as a part of the ATS-1 Biomedical Communication Project Evaluation at Stanford University are listed among the bibliographic references. (See REFERENCES)

CHAPTER II

SOCIAL GEOGRAPHY

II.A. VILLAGE ALASKA

Alaska occupies about 600,000 square miles, or 16 percent of the total area of the United States. However, its total population in 1970 was about 300,000, or 0.15 percent of the U. S. total. Approximately one-fifth (60,000) are natives.

II.A.1. The natural environment

The tundra in the north and the taiga in the south, with the wild Brooks Range as a dividing line, are the main environmental features of the Alaskan geography. (This section does not refer to southeast Alaska which is geographically distinct, being characterized by a more temperate marine climate, heavy rainfall, mountainous terrain, and dense coniferous forests.) As a consequence, the socioeconomic development of Alaska is framed by some peculiar factors of this natural environment: the light cycle, creating short summers with midnight sun and long winter nights, affects the biological cycles of nature and human behavior; the severe cold during two-thirds of the year, increasing the difficulties for human activities; the eternally frozen subsoil, permafrost, underlying 60 percent of the Alaska land mass. This inhibits the possibilities for excavation for cellars, cemeteries, wells, and pipelines. It also reduces the capacity to absorb sewage and drain water. Chemical and biological reactions and destruction are generally retarded at low temperatures, further complicating sewage and waste disposal. And as the ground underneath poorly insulated houses may not freeze even in winter, soil depressions that collect stagnant water under the houses are often formed. The natural food resources, formerly in abundance from subsistence fishing and hunting, have been reduced by ecological changes resulting from the arrival of white people. Today the food resources are meager and the bulk of Alaska's food supply is imported.

II.A.2. The Social Environment

Today there are two social formations in the Alaska society. One is the modern urban and relatively dense sector encompassing the three major urban centers, Anchorage, Fairbanks and Juneau, plus the strip parallel to the highway connecting Anchorage and Fairbanks; the other is the rest of the territory, Bush Alaska, occupied by one-fifth of the population (density 0.1 person per square mile) in widely dispersed settlements and hamlets. For centuries the people in the bush have tried to survive, maintaining their delicate balance with nature while absorbing innovations from contacting cultures. A century ago the native population, the overwhelming majority at that time, was several times larger than it is presently. (Lee, 1973)

Three main aboriginal ethnic groups live in Alaska today: 27,000 Eskimos, 18,000 Indians, and 8,000 Aleuts. (Lee, 1973) (There are several Indian groups in Alaska--including the Athabascan, the Tlingit, Haida, and Tsimshian--and two major Eskimo peoples.) Their ancestors came from Siberia and the northern Pacific, dating back to the Stone Age. While the Athabascan moved inland and southward along the great rivers, harvesting the inland game and the rivers for subsistence, the Eskimo settled along the northern and western coastal regions, and lived primarily off the sea and estuaries. The Aleuts, kinsmen of the Eskimos, occupied the Aleutian Islands where the sea provided them adequate food, and where they enjoyed a warmer climate. From 1940 to the present time, a dramatic cultural and economic shift has taken place among the native population, caused first by the military-related development of Alaska, and later by the discovery of minerals, gas and oil. These discoveries have made it profitable to extend Western civilization farther into Alaska. The nomadic and self-sufficient household components of the culture have been converted more and more into sedentary life and monetary economy.

The passage from well-knit social organizations with economic self-sufficiency and strong religious and cultural support, to a dependent economy, supported by outside resources (military, welfare and education, health care funds) and with a monetary basis, has caused an imbalance which is reflected in the sanitation and health situations. (See Chapter III)

Federal government activities have been the biggest contributor to Alaska economy since the beginning of World War II. In 1972, Federal outlays accounted for more than half of the State's economic base (Teleconsult, 1972). Exploitation of gas and oil resources will likely become the chief factor of the Alaskan economy. The expected increases in personal income, population, and state government revenues will undoubtedly change the Alaskan circumstances. Depending on the allocations of these resources, they can make a positive, neutral, or negative impact on the present serious problems of the majority of the natives, whose levels of employment and income, school achievement, physical and mental health, longevity and almost every other conventional measure of personal and social welfare were substantially lower than those for non-native Alaskans, or for the United States population as a whole (Teleconsult, 1972).

The costs of living and doing business are higher in Alaska than the U. S. national average: distance, market scale and climatic contingencies are mainly responsible. Furthermore, in Fairbanks the cost of living hits lower incomes hardest: in 1971 it was 137 percent of the national average for higher level incomes and 164 percent for lower level incomes. (Teleconsult, 1972)

Migration to the cities and disruption of the life in the villages has been the main consequence of the imbalance of the cultural exchange. However, new trends are appearing, both in the slowing of the migratory pattern away from the villages (although migration has not stopped, there is a new growth in the village population since the mid-sixties) and an upsurge of participation on the part of the natives in decision-making concerning their own lives and institutions. For example, the goal of the Tanana Service Unit of the Alaska Area Native Health Service (in its "Program for 1974" report) reads, "...to elevate the health status...to the highest possible level through active participation of native people."

II.A.3. Language

There are eleven major linguistic areas in Alaska, with fifty-six subdivisions. The widespread use of their native language and the avoidance of English, except for conversation with government people or other whites is common in much of village Alaska. However more than three out of four adult villagers were reported to speak and understand English well. (Alaska Natives and the Land, 1968) As in other parts of the U. S., the school system is reducing the use of the native language among youth in favor of English. (Teleconsult, 1972)

II.A.4. Geographic distribution

Seventy percent of the natives live in predominantly native villages. Of that seventy percent, three-fourths live in 167 native villages of less than five hundred population, mostly between 25 to 200 persons, and most of the other fourth live in six major native centers (1,000 to 2,500 population), all of them on the coast. Most of those who do live in predominantly non-native areas (30 percent of the total) live in the major urbanized areas.

Migration both to large cities and large native towns is occurring. The number of natives in cities (Anchorage, Fairbanks, Juneau, Kodiak, Sitka), and in large native centers (Kotzebue, Bethel, Barrow) has tripled in the last twenty years. Migration to the "lower 48" goes unrecorded, but appears to be less than one percent annually. (Alaska Natives and the Land, 1968)

However, as that same report indicates, "Villages are not vanishing from the scene today as is often assumed. There are twelve fewer separate native villages (with 25 or more population) than those indicated in the 1950 census, but more than 80 percent of the places which continue to exist are larger than they were seventeen years ago. More than half of these are growing more rapidly than the approximate rate of net natural increase. The aggregate population of native places today (1967) is a third larger than it was in 1950."

The depopulation of village Alaska stopped in the mid-sixties, but not the migration to the urban centers. Considering the difficulty in forecasting with confidence, a good generalization is that the native villages are not disappearing, and that migration out of the bush has been considerably less than the natural increase in native population, except in southeastern Alaska and along the highway system. (Teleconsult, 1972)

While it is possible to infer from past experience and similar cases that increased cultural contact with modern urban life (through outside controlled Western schools, mass media and travel) will increase the outflow from the villages, the resources and organization brought to the natives because of the Land Claims Act settlement may counter that trend to the extent that they are used to improve life in the villages and to increase self-government.

II.A.5. Political organization

Many villages in Alaska are organized for government only on a traditional basis. Others are chartered as cities under the Indian Reorganization Act, some are organized as cities under the laws of the State of Alaska, and a few have dual organizations. (Alaska Natives and the Land, 1968)

There are now 12 regional corporations (profit-making, with initial capital from Land Claims Act) and another 12 non-profit native associations in those regions. There is also a major statewide association: the Alaska Federation of Natives. The regional corporations were formed recently with the purpose of implementing the general development of each region on the basis of the native interest. For that purpose, they were invested with the power of administration of funds and rights that were recognized by the Land Claims Settlement Act in 1965.

II.A.6. Education

There are two main systems of public elementary schools in village Alaska: The State Operated Schools and those under the administration of the Bureau of Indian Affairs. Most of the villages have one school. Some communities and regions are attempting to gain more local control of their schools through incorporation (e.g. Arctic Slope Borough School District, City of Galena). There are only a few secondary schools and technical schools in Alaska, and most high school students living in the bush must temporarily live in boarding houses in the cities where the high school is located.

Two major universities provide higher education: the University of Alaska at College, with several community colleges throughout the State, and the Alaska Methodist University. In both there is a small but growing proportion of Natives.

II.B. COMMUNICATIONS

II.B.1. Transportation

The long distances, the scarcity of population and problems of the climate and terrain have reduced development of modern ground transportation in Alaska to a minimum. In 1970, about fifty thousand people lived in villages with no year-round ground transportation links with each other or with the rest of North America. Another fifty thousand lived on islands or mountain-ringed shorelines where they were accessible mainly by the State marine highways, a system of ferries visiting each community daily to weekly. As the Alaska Natives and the Land report indicates, only "a dozen native villages are on the State's limited road network. Two are on the route of the 540-mile

Alaska Railroad. Access to the other 170 or so is only by air, or seasonally by boat, snowmobile, or dog team."

In fall and spring, not all villages are accessible even by air. At the 45 villages without airstrips (outside of southeastern Alaska) for several weeks during fall freeze-up float planes are prevented from landing on the rivers, and the several weeks of spring breakup prevent ski-equipped planes from landing on winter ice. At least two villages, Atka on the Aleutian Chain and St. George in the Pribilof Islands, may only be visited by boat or float planes. Airstrips in villages, where they exist, are usually gravel.

In western Alaska, where most villages are located, surface-carried freight on ocean-going vessels arrives twice annually at the most.

II.B.2. Telecommunications

Isolation and distance between settlements, plus the rigorous natural conditions, increase the need for modern telecommunication in Bush Alaska. However, only 78 out of 180 native villages (population 25 to 1000) have commercial telephone service, either bush phone or regular commercial service. On the other hand, in the non-native communities (also 25 to 1,000 population) 78 out of 103 have telephone service.

TABLE II-1

Telephone Service in the Villages
April 1974
(Communities of population 25 to 1000)

	With phone	Without phone	Total
Predominantly native	78	102	180
Predominantly non-native	78	25	103
	156	127	283

See Attachment II.1 for these data tabulated by PHS Unit

An official report says, "Not all the villages have radio transmitters and receivers, and even if they do, communication may be made uncertain by climatic conditions. And since most of the transmitters and receivers are in State or Federal schools, their use is limited to official business and emergencies." (Alaska Natives and the Land, 1968)

With reference to the HF radio, the Teleçonsult report says:

> "Many other (villages) having no telephone communications rely on short wave radio for contact with the outside world. This is usually on a once-a-day scheduled basis when eleven land radio stations, strategically located around the State, meet schedules with village radio stations operated by the State or Federal school teachers, Public Health Service village aides, or some privately licensed radio stations in the villages.

> Messages can be relayed through the land radio stations for transmission over teletype circuits to other parts of the State or the country. Telephone phone patch calls are occasionally possible when radio signals are strong. At times, radio signals are so poor that just getting a message through is difficult, if not impossible. The service has not really had the use by the village general public that it could have, mostly because of the difficulties involved with it. And, of course, there is no privacy whatsoever. Aside from the radio operators at each end of the circuit being involved with the call, tuning in on the radio schedules by anyone with a standard shortwave radio is a popular pastime in the villages, and a substantial contribution to the famous Mukluk Telegraph."

(This lack of privacy does not apply to the satellite radio system where only the health aides' sets can receive the satellite signal.)

Most households have commercial radio broadcast receivers, generally battery operated.

Only one-third of the communities with population 25 to 1,000 have access to a television signal, most of them because of their vicinity to the big cities or to Air Force translators. A few of them have ETV stations which are used to to broadcast mailed videotapes. A few have cable television systems for retransmission of mailed videotapes. Of the at least 200 that do not have television at all, 159 are predominantly native. (Table II-2) Even the Anchorage and Fairbanks stations depend on physically transported videotapes for their programs.

Only four TV programs seen in Alaska in 1973 were broadcast live from outside Alaska. Economically viable TV interconnection with the rest of the U. S. awaits the start of U. S. domestic satellite service. (See Attachment II.2 for table by PHS Unit)

TABLE II-2 **Television Service in the Villages**
April 1974
(Communities of population 25 to 1000)

	No TV reception	Direct TV	TV with mailed tapes	Air Force translator	Uncertain
Predominantly native	159	7	3	6	1
Predominantly non-native	40	60	13	4	10
Total	199	67	16	10	11

CHAPTER III

HEALTH SITUATION IN ALASKA

III.A. GENERAL SITUATION

In a powerful paragraph the Medical Director of the Alaska Area Native Health Service summarizes the historic background of the present health situation in Native Alaska:

> "With him, the trader, the whaler and the miner brought the scourges of the times--the epidemic diseases of small-pox, influenza, measles, meningitis, and respiratory illnesses which decimated entire communities. Tuberculosis and venereal diseases were planted in virgin soil and thrived too well, the effects being present to this day. Increased mobility promoted the spread of these diseases. Alcohol, and the way to make it, was introduced. New food and eating habits fostering tooth decay and malnutrition were adopted." (Lee, 1973)

On top of that, the introduction to the bush culture of the market system without the creation of adequate employment, simultaneously with the imposition of foreign patterns of consumption of goods and services, has weakened the strength and vitality of the native population.

In 1954, just before the U.S. Public Health Service assumed responsibility for providing health care to the native people, a study team produced a report generally referred to by the name of the team leader Dr. Thomas Parran. The Parran Report shows that Alaska natives were the victims of sickness, crippling conditions and premature deaths at a rate exceeded in few parts of the world.

The main problems presented were tuberculosis, maternal and child health, mental, environmental and dental health. Only an inadequate health care system existed.

In 1972, The Alaska Area Native Health Service reported about the advances achieved in those areas (Lee, 1973). Tuberculosis, which used to be the cause of one-third of all the deaths, had been practically eradicated and was under reasonable control; deaths from infectious diseases other than TB, and diseases of pregnancy and childbirth, which were ten times that of the U. S. whites in 1954, were only 1.5 times higher in 1972. Infant mortality was also reduced by improvement in delivery conditions and medical care. In 1950 ten percent of the newborn died before the first birthday; that figure was three percent in 1970.

On the other hand, in the areas of mental health and dental health, while improvements have been achieved, parallel successes were not obtained. (Lee, 1973) New problems have arisen. These latter are in general related to sociobehavioral circumstances, and are reflected in increased rates of death from alcoholism, suicides and homicides, and in the increasing proportion of hospital admissions resulting from accidents, psychological disorders, and abortions.

(Attachment III.3)

III.B. HOSPITALIZATION TRENDS

The general trend in hospitalization rates of native patients is toward an increase in the number of outpatient visits (48 percent increase in absolute number from 1966 to 1970) against a rather stable trend in the number of inpatient admissions (around 270/1000). However there was a sharp reduction in the average length of stay (average of 19.3 days in 1966, 11.0 in 1972). This reduction is considered an indirect measure of progress of the system. (Lee, 1973) Meanwhile the expansion in the number of outpatient visits is attributed to increases in primary prevention, secondary prevention through early diagnoses and treatment and maintenance care of those with chronic diseases. (Table III-1)

Table III-1 ALASKA NATIVE HEALTH SERVICE
Direct and Contract Service Workload

Fiscal Years 1966, 1972

	Fiscal Year 1966	Fiscal Year 1972	Change
Admissions	12,697	14,481	+ 14.2%
Inpatient days*	199,081	123,048	- 38.2%
Avg. length of stay*	19.3 days	11.0 days	- 43%
Outpatient visits**	141,312	209,339	+ 48.2%

Source: Office of Systems Development. AANHS

* Does not include 'contract' hospitals

** Increase partly due to redefinition of the scope of this activity

In comparison with the U. S. rate, the number of native people admitted annually as inpatients is more than twice as high (270/1000 vs 123/1000). The main causes of hospitalization in 1972 were, in this order: accidents, delivery, otitis media, psychological disorders, senility and ill-defined conditions, diseases of the eye, pneumonia, diseases of the breast and female reproductive organs, diseases of the heart, and abortion. (Attachment III.3)

III.C. VITAL STATISTICS

Both birth and death rates have dropped in the past ten years. The birth rate in 1971 was 32.4/1000 (45/1000 in 1962), or 1.8 times the U.S. rate. The death rate has dropped from 16.8/1000 in 1950 to 7.4/1000 in 1970, less than the U. S. rate (probably due in part to the high proportion of young people among the total native population). (See Attachment III.1) The comparison of U. S./Alaska rates has not been adjusted by age.

An overall analysis of the causes of death in the whole native population shows a shifting pattern. In the words of Dr. Lee:

> "Accidents still remain the leading cause of death but influenza and pneumonia, together the number two cause in 1960, have dramatically shifted to fourth place. Early infancy deaths have dropped from third to seventh place, while heart disease and cancer have moved into second and third place,

> respectively, each just one rank below the ranking for the total U.S. population. The tendency noted is for ranking to line up in the same order as that of the general U.S. population. These shifts could be interpreted as resulting from an effective attack on infectious diseases through prevention and cure." (Lee, 1973)

III.D. HIGH PRIORITY HEALTH PROBLEMS

A whole new set of problems have increased their effects and pervasiveness. Reactions to the cultural clash, unemployment, the educational system and adaptation to the demands of modern life, are harder to approach than the strictly "medical" diseases. (See Attachment III.4)

III.D.1. Mental disorders: As causes of death, of hospitalization, or reasons for visits to the medical personnel, the incidence of mental disorders is growing sharply. Alcoholism is a health problem of growing importance. Haraldson (1972) summarizes the point:

> "The consequences of alcoholism are many and with high incidence in the statistics (e.g. of violence, accidents, cirrhosis of the liver and family breakups.) Alcoholism is considered a direct or contributing cause in 20 percent of all deaths."

A growing use of hallucinogenic drugs has been reported. The rate of hospitalization for mental disorders jumped from 5.3 per thousand in 1966 to 19.3 per thousand in 1972. (Attachment III.3) The native rate of suicides and homicides in 1968 was double the rate for whites.

III.D.2. Venereal diseases: The rate of gonorrhea in Alaska is the highest in the USA, and the number of syphillis cases is growing steadily. In 1970 the reported cases of gonorrhea showed a rate of 888 per 100,000.

III.D.3. Otitis media: Special campaigns are under way to eradicate this most common childhood illness. About one-quarter of the natives have had more than one episode of draining ear at some time in their lives. The results of the campaigns are encouraging. (Fifty to ninety percent of children surgically treated in Anchorage have had continuing good results).

III.D.4. Water and sanitation: Solutions that were adequate for nomadic or subsistence traditional life are not suitable for the requirements of modern life. Permafrost and the extreme climatic conditions make the installation of water supply and sewage disposal systems difficult. The land is hard to excavate, pipes freeze and break, and sewage seeps out. Experimental systems are being tried, but the obvious additional costs make it difficult to implement them widely.

III.D.5. Housing: The natives, long accustomed to the outdoor life (hunting and fishing with high mobility), now spend more time indoors at home. The scarcity of financial resources to buy modern houses and the lack of modern designs based on locally available materials (rocks, logs, etc.) have resulted in the building of substandard houses where sanitary and psychological discomfort abounds.

> "It is generally accepted as a fact that Eskimo substandard housing contributes to the high incidence of a series of environmentally related diseases such as acute viral and other respiratory diseases, pneumonia, otitis media, streptococcal throat infections, rheumatic diseases (with heart and kidney involvement), skin diseases, accidents, and even some mental disorders."
> (Haraldson, 1972)

III.E. ORGANIZATION OF THE HEALTH DELIVERY SYSTEM TO NATIVE ALASKANS

Multiple public agencies and services plus the private sector are the providers of social and health services to the natives.

The first level of care is provided in the villages which are covered by about 180 health aides, paramedical personnel who provide primary care to their fellow villagers and are linked by radio to the doctors at the Native Health Service hospitals. About once a month nurses and/or doctors visit each village for ambulatory care and preventive treatments. The villages are grouped in seven Public Health Service Units, each of which has its hospital, and in some cases a town clinic, served by a public health nurse. (Lee, 1973) All these seven units comprise the Alaska Area Native Health Service, a geographic section of the Indian Health Service (PHS-HEW). The headquarters are in Anchorage with an area director and a central hospital (the Alaska Native Medical Center, ANMC) serving the whole region. In some areas or for some problems, the Service contracts with private or public medical centers the treatment of native patients. The Alaska Native Health Service also deals with environmental sanitation, housing, water supply, and sewage disposal. (Haraldson, 1973a)

Medicare and Medicaid support is available to Natives qualifying for it because of low income, age, blindness, or disability, and for families with dependent children.

The Office of Economic Opportunity supports two "regionalized consumer-controlled health delivery systems serving Eskimo people" in Bethel (the Yukon-Kuskokwim Health Corporation) and in Nome (the Norton Sound Health Corporation).

The Department of the Interior, through the Bureau of Indian Affairs, cares for education of native children, land problems, unemployment, and welfare in general.

The Department of Housing and Urban Development supports development of low-cost housing in native settlements.

The State of Alaska is responsible to all Alaskans for: communicable diseases in general, tuberculosis control, mental health, maternal and child health and family planning, public health nursing, nutrition and rural housing. (Haraldson, 1973) It also provides free laboratory services for private physicians attending Native people. The Alaska State Department of Health and Social Services is the main responsible agency. There are also local autonomous health agencies at the borough level.

As Haraldson points out (1973), "Due to the rather complicated organizational pattern of health services with responsibilities shared..., considerable coordination problems are involved in the planning and administration of native health services".

Indeed, quite recently the three top planning and advisory agencies (the Alaska Native Health Board, the Indian Health Service, and the

State Department of Health Social Services) got together to analyze the allocation of the $100 million combined health budget. (Alaska Federation of Natives Newsletter in Tundra Times, February 27, 1974) At the meeting "much time was spent identifying who does what under the name of health" in Alaska. According to the newspaper report, the Alaska Native Health Board stated that "health problems are basically the same as 100 years ago and are just beginning to be addressed".

III.F. A COMPARISON WITH THE HEALTH CARE SYSTEM FOR NATIVES IN THE CANADIAN NORTH (by Heather Hudson)

The Alaska health care delivery system may be compared with the system used by the Canadian Government, in which most remote native communities in the Canadian North are provided with a resident nurse and a nursing station which consists of a clinic, a few beds, and living quarters. The larger stations have two or three resident nurses. The nurses are linked to regional hospitals by telephone or HF radio telephone. Some smaller communities are served by native aides who report by HF radio to nurses in the larger settlements.

The nurses come from southern Canada and foreign countries such as Britain and Australia. The turnover rate is high. Dr. Sixten S. R. Haraldson of the World Health Organization concludes that the Alaskan approach of using trained native aides with communication to doctors avoids many of the problems of the Canadian system. "Training the Eskimos as medical aides means they stay on the job, so avoiding the high turnover rate which plagues Canada's northern health service." (Haraldson, 1973b) He found that infant mortality among Alaska Eskimos was much lower than for Canadian Eskimos, quoting the Alaskan figure of 20 deaths per thousand live births vs. 97.8 per thousand for Canadian Eskimos. Haraldson notes that Alaska spends about $700 on health care per Eskimo per year to cover all health costs, whereas Canada spends $740 to cover 60 percent of costs. "Canada seems to be spending more and getting less." (Haraldson, 1973b)

On the other hand, Dr. carolyn Brown, a physician practicing in Anchorage and a consultant to Stanford University, points out that the Alaskan system is unplanned. Different agencies overlap each other and it is fragmented in its operation and coverage, while the Canadian system is well planned and unified. However, both agree that using trained native health aides is the cheapest way to raise the standard of service in remote areas.

CHAPTER IV

BACKGROUND AND PURPOSE OF THE ATS-1 SATELLITE EXPERIMENTS

IV.A. BACKGROUND

The presence of the ATS-1 satellite in geostationary orbit provided the opportunity to conduct experiments between small ground stations located both in remote places in Alaska and in urban centers to verify the possibility of having reliable telecommunications between them. The National Aeronautics and Space Administration (NASA) has made time available on the first of the Applications Technology Satellites (ATS-1) launched in 1966, but still operating satisfactorily for voice communication. The Lister Hill National Center for Biomedical Communication of the National Institutes of Health, Department of Health, Education and Welfare, through a contract with the University of Alaska, has funded the installation and operation of low-cost ground stations in several Alaska locations with the basic purpose of improving health care delivery to the villagers by health aides who are able to consult remote doctors (see list, Attachment IV.1). Stanford University received a contract from the Lister Hill Center to carry out an evaluation of the ATS-1 biomedical communication system in Alaska.

As originally outlined in the Lister Hill Center report, "A Satellite Communications Project for the Pacific Northwest and Alaska" (October 1970), the fundamental aims of the experiments included both technical and specifically biomedical communication matters. These goals were to:

--determine the degree to which satellite communications technology can be used for biomedical communications in remote areas where common carrier telecommunications services do not exist or are severely limited;

--provide technical experience which will be of use in the design and development of future operational satellite systems and medical services;

--gather technical data to be used in the design and development of small, effective, and economical satellite communications earth terminals;

--gain experimental data designs of baseband communications equipment (e.g. ECG devices, teletype terminals) to be used in conjunction with both satellite and terrestrial transmission systems.

--conduct controlled experiments to determine effective methods of providing health care education and medical consultations to geographically isolated locations.

IV.B. THE OPERATIONS AND THEIR EVALUATIONS

In this context, the main task of the evaluators was to analyze the operation of the biomedical communication system, its human and organizational components, and its impact upon the health delivery system, its personnel, and its users. This evaluation required both an analysis of the actual functioning of the system and comparative studies of existing communication alternatives.

More specifically, the research carried out included:

a. A quasi-experimental comparison of the communication performed in the aide-to-doctor system, when using HF radio and when using satellite radio (Ch. V and VI.A).

b. An analysis of the performance of the aide-to-doctor exchange, both for the quality, frequency, and duration of the exchanges, and for their medical content (Ch. VI.A).

c. An analysis of the impact of the satellite communication on the health aide behavior, and of their attitudes toward the system (Ch. VI.B).

d. A quasi-experimental analysis of the impact of the satellite radio link on the hospitalization rates of the villagers served by it compared with those villagers served by HF radio (Ch. VI.C).

e. An analysis of the exchanges between a physician on a remote island and his consulting colleagues at a major medical center (Ch. VIII).

f. A quasi-experimental evaluation of paramedical education by satellite, comparing the learning scores of nurses obtained after participation in a Coronary Care Nursing Course, delivered both in face-to-face situation in a school setting and by satellite to nurses stationed in remote clinics (Ch. IX).

g. Alternative systems to provide health communication services were assessed. The results include hardware, satellite link, and cost analysis (Ch. XI).

The contract was awarded on January 1, 1971 with some modifications made later on, and the satellite radio ground stations began operations in August 1971. The experiments were carried out from that period on. Data from this ATS-1 experiment are being used as baseline data for the ATS-6 experiments on satellite transmission of video and health information messages and their effects on health care.

CHAPTER V

TECHNICAL EVALUATION OF SATELLITE SYSTEM PERFORMANCE

V.A. BACKGROUND: THE ATS-1 EXPERIMENT--COMMUNICATION BEFORE AND AFTER SATELLITE RADIO INSTALLATION

During the summer of 1971, ground stations were installed at 26 communities in Alaska for two-way audio communication via the NASA ATS-1 experimental satellite. Nine of these stations were located in villages in the Tanana Service Unit which are served by native health aides. Other ground stations in the Unit were installed at the Tanana hospital and Fort Yukon where there is a nurse. Ground stations were also located at the Alaska Native Medical Center (ANMC) in Anchorage and in 13 other communities, several of which had doctors. The Alaska control station (Minitrack) is at the University of Alaska in College, near Fairbanks.

The primary use of the ATS-1 network has been for a daily doctor call between the doctor at Tanana and the remote health aides in the Tanana Service Unit. In 1973, six ground stations were moved from other sites where they had received little use to an additional five villages in the Tanana Service Unit. (See Attachment IV.1) Prior to the installation of the satellite radios in some villages, all of them had HF communication and the doctors at the Tanana Hospital tried to achieve the daily doctor call through those HF radios.

V.B. METHODOLOGY

In an attempt to isolate the effects of introduction of the new technology from other factors influencing health care delivery in rural Alaska, a quasi-experimental design was imposed on the basic data. A group of nine villages were designated as the "experimental villages". These were Allakaket, Anaktuvuk Pass, Arctic Village, Chalkyitsik, Huslia, Nulato, Ruby, Stevens Village, and Venetie. All of them were equipped with satellite-radio replacing the HF radios being used by the health aides. A tenth village with satellite radio in the Tanana Service Unit, Fort Yukon, was excluded from this analysis because the presence of a nurse and the availability of a telephone made the health care delivery situation in that village quite different from the others.

To examine the difference attributable to the satellite radio, statistics were gathered for the year immediately before the introduction of the satellite ground stations. Some of the changes from one year to the next might have occurred without the introduction of the satellite radios, however. To provide an appropriate baseline for comparison, a group of villages in the Tanana Service Unit which did not have satellite radio were studied during the same three-year period. (Mid-August of 1971, the average date of satellite ground station installation, was used as the dividing point for the before-after comparison in the control villages.) No other event that could have differentially affected one group of villages was detected. Doctor-initiated doctor call sessions were held before and after the satellite installation in all villages, experimental and control ones. No turnover of health aides occurred to affect the experimental data.

V.C. TECHNIQUES

For purposes of this technical evaluation, the radio logs at Tanana Hospital and at the Minitrack Station at College were examined to determine the frequency of radio contact between Tanana and each of the villages during the three-year period and the quality of the signal. For the nine experimental villages, the data presented below include the calendar year immediately before and immediately after the installation in each village, and a second year, beginning in October 1972. (See Minitrack radio log as Attachment V.1, and Tanana radio log as Attachment VI.2.)

For the four control communities of Beaver, Hughes, Koyukuk and Rampart, the radio contact is reported for the year before and after the average installation date of August 17, 1971. (Table V-1) Only four control villages were used for this analysis because the villages of Birch Creek, Circle and Eagle (used as controls in other analyses reported below) did not appear in the radio logs in this period; they apparently had no radio contact at all with Tanana Hospital. During the first year of the satellite period, the satellite was not available for 27 days. Also, the health aides were not required to answer "doctor call" on weekends if they had no patients to discuss. However, in all instances, the percentage of days with radio contact was calculated on the basis of a 365- or 366-day year.

Table V-1. Days of Radio Contact with Doctor Before and After Installation of Satellite Ground Station

	BEFORE		AFTER			
	(1970-1971)		(1971-1972)		(1972-1973)*	
	average number of days	% of poss. days	average number of days	% of poss. days	average number of days	% of poss. days
Experimental Villages (9)	51.7	14.0	270.2	74.0	310.0	85.0
Control Villages (4)	44.0	12.0	24.3	7.0	N/A**	N/A**

* 10-1-72/9-30-73

**Three of these four villages (Beaver, Hughes, and Koyukuk) had satellite radios installed in mid-April 1973. The fourth, Rampart, continues operation with HF radio, but no record of contact appears in the Tanana Hospital log.

V.D. ANALYSIS OF THE RESULTS

The change in radio contact in satellite villages amounts to an increase of more than 400 percent for the first year after and more than 500 percent for the second year following satellite radio installation. These differences are statistically significant despite the small number of villages involved (first year, $t = 14.1$, $df = 8$, $p < .001$; second year, $t = 22.3$, $df = 8$, $p < .001$).

The percentage drop in the villages with high-frequency radio contact is not statistically significant, and may be just random fluctuation. The first year report suggested that if the change did represent a decline, it might represent deterioration of the high-frequency equipment as contrasted to the satellite radio, or a decline in the doctors' perseverance in attempting to make contact via high-frequency radio. The lack of data for the second year (due to the fact that no record of contact appears in the log for the control villages) made it impossible to be more definite.

V.E. INFLUENCE OF THE LOCATION OF THE RADIO TRANSCEIVER

One alternative hypothesis to explain the increase in "contacts completed" after the satellite ground station installation was the fact that these transceivers were placed in the homes of the health aides, rather than in less accessible areas, such as schools, community halls, etc. To control for the possible effect of the change in the location of the radio transceivers, four villages with both HF radios and satellite radios located in the home of the health aide were compared with five villages where the radios were not previously located in the health aides' homes. (Table V-2)

Table V-2. Percentage of Days on which Radio Contact with Doctor was Made

	Year before Satellite (1970-1971)	First year after Satellite (1971-1972)	Second Year After Satellite (1972-1973)
4 villages which had HF radio in Health Aide's home	21.0	74.0	89.0
5 villages which had HF radio elsewhere than Health Aide's home	11.5	73.0	82.2

The data demonstrate that having the HF radio in the health aide's home led to more frequent radio contact. However in those villages with "at-home" access to HF radios, contact was made on only one day in five.

V.F. COMPARISON WITH VILLAGES WHERE SATELLITES WERE INSTALLED IN 1973 ("NEW SATELLITE VILLAGES")

In April 1973, satellite radios were installed in four additional villages at the request of the residents. This group of villages--Beaver, Eagle, Hughes, and Koyukuk--offered an additional possibility of comparison between this new group and the villages where the satellite had been operating for more than a year. These "old" satellite villages were used, therefore, as a control group, and the four "new" satellite villages were the experimental ones. In both groups, the data for the year "before satellite" reflects the operation of biomedical telecommunication during 1971. The data for the "first year after satellite" reflect the operation of the biomedical telecommunication during 1972 for the old villages and the estimate for the calendar year of 1973 for the new satellite villages.

The data presented in Table V-3, following, confirm the previous analysis---that the installation of satellite radios increases dramatically both the number of contacts completed and the number of medical cases treated.

Table V-3 "Old" and "New" Satellite Villages

	Before	First Year After
Days with Radio Contact with Doctor		
New satellite villages (4)*	44.0 (12%)	278 (76%)
Old satellite villages (9)	51.7 (14%)	270 (74%)
New medical cases treated (average and episodes per 1000 inhabitants)		
New Satellite villages (4)*	24.7 (286)	158.4 (1,604)
Old Satellite villages (9)	47.1 (330)	184.6 (1,291)

*In the sample of 4 villages, one of them (Rampart) was replaced in the analysis for the "first-year-after-satellite" period by another village (Eagle).

V.G. ONE TYPICAL YEAR OF "DOCTOR CALL"

During 1973 it was possible to collect enough data to portray in depth the operation of the satellite radio system, its reliability and the medical services it provides. By 1973, the satellite was already a fact of life for the doctors and participating villages. Possible novelty effects and periods of adaptation were over. The hardware was no longer brand new and received average maintenance. The villagers who were the final beneficiaries of the system had evidence of its advantages and limitations. In 1973, satellite radios were installed in four more villages which allowed for comparison between newcomers and experienced health aides.

V.G.1. The Setting in the Tanana Service Unit

Doctors at Tanana Hospital communicated daily with health aides at thirteen villages and with registered nurses in charge of the clinics at Fort Yukon and Galena. Of the thirteen villages, nine had been using satellite radio since August 1971, and four since April of the year under analysis. The nurses at Fort Yukon and Galena also had telephone links to the hospital and frequently also sought consultation from the physicians at the Fairbanks Native Health Center.

All the health aides had performed similar tasks with satellite or HF radio for communication prior to the year under analysis. Two doctors at the hospital had been working with the satellite radio system since early 1972, and a third doctor was added as a radio consultant in mid-1973.

The satellite voice channel was operating at full power, and maintenance of the equipment was assured by the Geophysical Institute of the University of Alaska, at College.

The population in the thirteen villages served by health aides and satellite radio was about 1,700 persons, of whom more than 95 percent were Natives. With the exception of Anaktuvuk Pass, which is an Eskimo village, all the others are predominantly Athabascan Indian communities.

V.G.2. Performance of the System

The major figures for the system performance during this year are as follows:

V.G.2.a. Contacts completed: 86 percent of attempted contacts were successfully completed. Technical and human problems (health aide away hunting or busy with personal affairs, etc.) account for the remaining 14 percent. The village with the most completed contacts had 96 percent, the one with the least completed, 63 percent. The percentage of contacts completed remained reasonably stable over the year (maximum, October, 91 percent; minimum, June, 83 percent).

The villages joining the system in April 1973 had a similar proportion of completed contacts to those villages already operating via satellite.

V.G.2.b. Positive traffic (traffic with medical content): On 67 percent of the total village days (or, in other words, of the total possible contacts), the average health aide discussed or exchanged medical messages (either patient consultation and/or medical administrative matters). January and February had the lowest percentage of medical content (on about 53 percent of the total days). (See Attachment V.2)

The variation among villages is notable. There was one village (pop. 159) with content to transmit on 88 percent of all the days of the year, while another village (pop. 84) had medical traffic on only 48 percent of all days.

V.G.2.c. Negative traffic: On 19 percent of all days (or 34 percent of the "completed contacts"), there were "neither patient consultations nor administrative matters to exchange that day". In colder months there tended to be more contact days without medical traffic than in milder months.

V.G.2.d. The quality of the signal: The signal was rated at Minitrack daily for contacts with every village on a five-point scale for strength and intelligibility.

The strength of the signal was rated in the two top categories of the scale in more than 98 percent of the contacts, and in 84 percent of them it was rated in the top category.

There were no clear seasonal strength variations. In April and May, however, there was significant increase in the number of contacts with strength rated in the second best category (25 percent). Some villages transmit with considerably better signal strength than others. The worst village had 57 percent of the contacts in category 4; the best had only 4 percent rated 4; and almost all others were in category 5.

The intelligibility of the signal was rated for more than 95 percent of the contacts in the top two categories, and for 62 percent of them in the top category. (Category 4, readable with practically no difficulty; 5, perfectly readable.) Some of the villages had an average of 84.2 percent in the 5 category, while others had only half of their contacts in that category.

CHAPTER VI

EVALUATION OF REMOTE HEALTH AIDE-TO-DOCTOR CONSULTATION VIA SATELLITE

In the previous chapter data analyzed show the increase in the frequency of contacts between health aide and doctor, and their high signal quality.

In this chapter the operation and possible effects of the link between health aide and doctor are explored. This chapter is divided into four main sections: VI.A., analyzing the biomedical content of the telecommunication (number of consultations, diagnoses, severity, predicted effects, etc.); VI.B., describing in depth the role of the health aide; VI.C., exploring its possible consequences on hospitalization rates; and VI.D., a discussion of conclusions.

VI.A. HEALTH AIDE-TO-DOCTOR COMMUNICATION

The communication between health aide and doctor is analyzed in this section quantitatively and qualitatively. The first part compares the number of medical episodes treated before and after the installation of the satellite stations, and describes in more detail the ones held during a typical year (1973) of full operation of the system, including the emergency calls. A more qualitative content analysis of those exchanges follows, analyzing the type of visit consulted on, the diagnoses, the severity, the management plan proposed, and the predicted effects on outcome.

VI.A.1 Medical Cases Treated

The radio logs at Tanana and the Minitrack station at College also permitted an analysis of the number of new episodes discussed by the doctor with the health aide in each of the villages contacted during doctor-call. Compared to HF contacts in the year previous to satellite installation, the number of cases managed by satellite radio showed almost a three hundred percent increase in the first year, and more than four hundred percent for the second year, against a background of a slightly declining number of patients treated in the HF radio villages. Table VI-1 shows the number of new episodes in the experimental and control villages in the year preceding and in the two years following introduction of the satellite radio. (A "new episode" is any form of patient contact other than follow-up visits within a few days.) The increase in the satellite cases was statistically significant (first year: $t = 12.5$, $df = 8$, $p < .001$; second year: $t = 23.4$, $df = 8$, $p < .001$). (Table VI-1)

Table VI-1 New Episodes Handled by Teleconsultation

	Before Satellite	After Satellite	
	(1970/71)	1st year after (1971/72)	2nd year after (1972/73)
9 Satellite Villages	47.1 (330)*	184.6 (1,291)*	290.0 (2,021)*
4 HF Radio Villages	24.7 (286)*	15.0 (173)*	N.A.

*Episodes per 1,000 inhabitants

VI.A.2. The Biomedical Communication During a Typical Year

VI.A.2.a. Data Sources

As we mentioned before (Ch. V.G) an in-depth analysis of the health aide-to-doctor communication was done on the data available for 1973.

The data used in this subsection stem from two basic sources: the logs kept at the Minitrack Station at College and records kept by health aides. Information from a previous analysis of emergency calls by Dr. Brian Beattie has been included.

VI.A.2.b. Patient consultations: Consultation is sought in about two-thirds of the cases seen by the health aide. This estimate is based on an in-depth analysis of one health aide's records. The health aides of the thirteen villages made 3,020 patient consultations in 1973. Given that the total population of these villages is 1,700, and four villages entered the system in April, this amounts to about 2.0 radioconsultations per person annually, or around 10.6 radioconsultations per average family (5.3 persons). (U. S. rate for doctor visits: 4.3 per person.)

There are large intervillage variations in the rate of radioconsultations per capita (maximum 3.7, minimum .95). Not enough information is available to relate this in any way to the health or sanitation conditions of the village. Variables in the behavior of the health aide are probably the major factor of the difference in the rate.

In 43 percent of all possible contacts (number of days per year times number of villages) there was at least one patient consultation; in some villages patient consultations occurred on two-thirds of the days; in some others, on only one day in four.

VI.A.2.c. Seasonal variations: There are seasonal variations in in the number of patient consultations per month. Winter and summer months have a higher number of patient consultations than spring and fall months. The patient consultations per possible contact for each month were as follows:

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
.89	.70	.73	.54	.55	.71	.75	.84	.77	.66	.67	.72

The yearly average was .71.

VI.A.2.d. Administrative matters exchanged: Placement of orders for supplies, drugs, checking on prescriptions, inquiries about use of drugs after freezing or after expiration dates were the most frequent non-patient matters exchanged. The second most frequent were inquiries relating to transportation, the whereabouts of the X-ray team, the dentist, the nurse, a traveling doctor, or the mail plane.

Each village discussed an average of 282 items per year, or .95 items per possible contact (maximum 1.9; minimum 0.5). The variation across months of the year was not seasonal (maximum 1.2; minimum 0.7). 23 percent of the total contacts had administrative matters as their only content.

VI.A.2.e. Time elapsed: During the full year, the thirteen villages used 13,944 minutes (232 hours) of satellite time. This was an average of 4.3 minutes per average day per village (4.8 minutes on weekdays and 2.6 minutes for weekend days), or about 9.3 minutes per person per village annually. Out of that time, 72 percent was used for patient consultations and about 27 percent for medical administrative matters. The average patient consultation required three minutes, and the average administrative item one minute. There were big variations between villages only partially accounted for by the variations in population between villages. (The maximum average contact for a particular village was 7.0 minutes; the minimum 3.4 minutes.) Weekend contacts were about 45 percent shorter than weekdays. There were no important variations in the time spent per month. All months had between 1200 and 1350 minutes with the exceptions of August (1539) and September (959). This amount of minutes excludes the exchanges with other villages or localities outside the thirteen under analysis (e.g. Fort Yukon, Galena, St. Paul Island). The total satellite time used was larger.

VI.A.3. Emergencies

The lack for the village aide of immediate contact with the hospital in emergency cases was a factor in disabilities and deaths. An analysis done by Brian Beattie, M.D. (Hudson, 1972) on emergency cases showed that:

a. Lack of communication within a reasonable time made a difference in the outcome of four cases out of a total of 10 deaths which occurred in the period he studied.

b. For emergency contacts, the villages where satellite radio was in use had a better percentage of contacts achieved within a reasonable time than those equipped with HF radio.

However, at the time of that study the health aides in the "satellite villages" had to wait to be called in order to have contact with the doctor. They could not call him. After that study, "alarm buttons" were installed in the health aides' houses, to call the hospital in emergency situations. After the installation of those buttons in late 1972, no case was recorded as not having been achieved within a reasonable time.

During 1973 there were 45 emergencies recorded, some of which involved more than one patient. Seventy percent of them resulted in evacuation of the patient to the hospital, and twenty percent were resolved by consultation with the doctor. The remaining ten percent were either labelled as "non-medical emergencies" or no information about their nature was recorded.

The following is a list of emergencies for which the alarm buttons were activated during May 1974:

1. Koyukuk activated the medical alarm signal at 1800Z on May 2. An 18-year old in labor; arrangements were made for air evacuation to Tanana.
2. Nulato activated the medical alarm signal at 1730Z on May 6. A patient with chest pain; treatment recommended. Nine minutes used.
3. Nulato activated medical alarm signal at 0538Z on 14 May. Patient in severe pain and depression. Had recently had surgery and radiation treatment for cancer. Air transportation to Tanana arranged for following morning.
4. Hughes activated the medical alarm signal at 0604Z on May 29. Patient with lower abdominal cramps. Treatment advised and air evacuation to Tanana arranged.

(From University of Alaska Geophysical Institute Informal Monthly Progress Report dated June 17, 1974.)

VI.A.4. The Content of the Aide-to-Doctor Radioconsultation

The health aide provides the first level of care in the remote villages, and is responsible for all health care activities during the long periods of time between physician visits to the community. In thirteen villages of the Tanana Service Unit, the aides contact the consultant physician at Tanana Hospital by satellite radio daily at scheduled times. A "sample" transcript of the kinds of interactions carried on over the satellite is included as Attachment VI.9. It is based on actual consultations but has been altered to preserve medical confidentiality. About two-thirds of the patients they see are discussed with the physician. What is the medical content of these exchanges? What conditions are the most frequently discussed? And with what effects in terms of treatment? How many of the cases discussed are transferred to the hospital? These questions are analyzed in this section.

VI.A.4.a. Methodology

Questionnaires and codes were developed at Stanford which asked the physician consultants, Drs. Crooks, Britton, and later Hardy, of the Tanana Hospital, to rate various parameters of the interaction. (Attachments VI.2 and VI.3) The period under analysis, the latter half of 1973, includes summer months and the extremely cold late months of the year. It does not, however, include late winter. No significant variation occurred between the warm and the cold seasons either in the number of encounters or in the proportion of various diagnostic categories. There were 2,004 physician-aide patient-related encounters during the evaluation period. Satisfactorily coded information was obtained on an average of 82 percent of entries. For the different variables the percentage of satisfactorily coded information was: severity, 86 percent;

type of encounter, 90 percent; management change code, 79 percent; and outcome code, 70 percent. (The outcome code completion rate rose to 77 percent after some confusion over the instructions was clarified.)

VI.A.4.b. Coders' Reliability (by Dennis Foote)

In order to verify that the doctors use the codes in similar ways, correlation coefficients were calculated between the numbers of cases each doctor assigned to each category of the codes. This is not a rigorous reliability coefficient, because the doctors have not judged the same cases, but it will provide a general indication of the similarity between each pair of the doctors.

Cases in which doctors failed to record the codes were excluded from the analysis. Because the degrees of freedom for the correlation coefficients are quite small, interpreting the actual magnitude of the coefficient is very difficult. For example, a correlation with two degrees of freedom must be .900 before it is significant even at the .05 level. Higher correlations must be obtained for more stringent significance levels. Consequently, the following table reports the level of significance of the inter-doctor correlations, rather than the actual correlation coefficient. The smaller the number, the stronger the similarity is between the two doctors' use of the codes. The obtained coefficients that were significantly different from chance range between .9159 and .9999.

		SIGNIFICANCE LEVEL OF CORRELATION COEFFICIENTS BETWEEN DOCTORS:		
CODE	DEGREES OF FREEDOM	DOCTORS 1 AND 2	DOCTORS 1 AND 3	DOCTORS 2 AND 3
Visit	1	.01	.01	.005
Travel	2	.005	.005	.005
Severity	6	.005	.005	.005
Management	2	Not sig.	Not sig.	.05
Outcome	2	Not sig.	Not sig.	.025

As can be seen from the table, the doctors use the codes quite similarly, with the exception of Doctor 1 on Management and Outcome codes. On those two codes, Doctors 2 and 3 use the codes in the same way, and Doctor 1 uses them differently from either of the other doctors. However, it must be remembered that these are not true reliability coefficients, because the doctors have not rated the same cases. Thus, it is not possible to conclude that Doctor 1 uses the codes unreliably; health aides may confer with him on different types of cases, or he may have an intervention style that is different from that of the other two doctors. What can be concluded from this analysis is that, on the whole, the doctors apply the codes in a consistently similar pattern.

VI.A.4.c. The patients

The encounters referred to native patients of all ages. As we have seen (Chapter V), the average native in the village is likely to be the subject of two consultations per year. The age distribution of the patients tends to follow the age pyramid of the village population with predictable increased utilization in the early childhood and older population groups. Twenty-two percent of the cases involve children three years or under, but this group constitutes only 15 percent of the total native population. This high rate is consistent with the fact that infant mortality in this area is 40 percent higher than in the rest of the U. S. (Number of deaths before the first birthday per 1,000 live births in 1970: Alaskan Natives, 28.5; U. S., all races, 19.8.)

Table VI-2 Age Distribution of the Cases Consulted

Age group	Cases (Number)	Cases (Percent)	Percent of the age group in the Native population
1 - 3	330	22.2	15.0
4 - 13	352	23.7	29.3
14 - 23	217	14.6	18.5
24 - 33	185	12.5	14.1
34 - 43	107	7.2	9.6
44 - 53	99	6.7	6.8
54 - 63	84	5.7	3.9
64 and over	110	7.4	2.7
	1,484	100.0	100.0
Unreported	520		
Total cases June-Dec 1973	2,004		

Source for age distribution data: Alaska Natives and the Land, 1968.

VI.A.4.d. The diagnoses

There were 26 diagnosis categories. The categories are based on the major headings of the Diagnostic Code List for the Ambulatory Patient Care Report given in Appendix III of Chapter 3 of the Indian Health Manual, TN No. 71.5, 10/5/71. Only minor adaptations have been made. The most frequently used categories were respiratory disease, ill-defined symptoms, skin difficulties, ear problems, and accidents. (Table VI-3) These five categories accounted for 63 percent of all recorded encounters.

The distribution among villages is relatively homogeneous. However, a few villages have special patterns, such as Hughes, where respiratory cases appear more often and digestive problems are more numerous. The populations of the villages are quite small (average 130 persons), and the presence of one individual with chronic illness necessitating frequent health care may have a significant effect on the total village utilization figures. Since patients were not coded individually it is not possible to answer the question of how much the "individual patient" may have contributed to these special patterns.

VI.A.4.e. Severity

The severity-complexity code was scaled from one to eight, the higher numbers indicating a more severe-complex problem. During the period under analysis, only one-half percent of the cases were considered as very severe and complex (categories 7 and 8). Two-thirds were considered category 5, evaluation of a minor symptomatic problem with some risk of complication. (Table VI-4)

Table VI-3 Incidence of Different Diagnoses in the Satellite Radio Consultations

Diagnosis	%	Diagnosis (n=2,004)	%
Respiratory	20.5	Urinary	1.7
Ill-defined symptoms	12.4	Birth control	1.4
Ear problems	10.8	Infectious diseases and parasites	1.2
Accidents	9.0	Mental disorders	.9
Eye	4.9	Blood, neoplasm disorders	.4
Digestive	4.7	Nervous system	.3
Supplemental tests and followups	4.0	Male genitalia	.2
Female genitalia and breast problems	3.7	Endocrinal, nutritional and metabolic	.1
Musculoskeletal and connective tissue	3.1	Other non-diagnosis patient-related issues (drug reorders, travel)	12.1
Dental	2.6		
Pregnancy, birth and puerperium	2.0		
Circulatory	1.7		

OVERALL TOTAL: 100%

Table VI-4 Severity-Complexity of the Cases Consulted

	Number of consultations	Percentage
1. Simple question about medication, reaction, or use of household remedy, etc.	71	4.1
2. Patient counseling about proper health habits, social or psychological problems	61	3.6
3. Routine screening, history, and physical on an asymptomatic individual, e.g., school or athletic evaluations	79	4.6
4. Followup of and resolving acute problem that has been under treatment	302	17.6
5. Evaluation of new minor, but symptomatic problems related to a particular organ system, URI, urinary tract, etc., with little potential to become severe problem or chronic disease process with little potential for mortality	1108	64.7
6. Evaluation of new moderately severe problem with potential for deterioration to severe problem or to disability or chronic disease process with moderate potential for mortality	84	4.9
7. Evaluation of acute problem producing severe symptoms or potential disability or a chronic process with high potential for mortality	6	.4
8. Evaluation of continuing severe problems of life threatening proportions requiring analysis of several diagnostic and therapeutic possibilities and frequent evaluation of course and therapy	1	.1
	1712	100.0
Unreported severity	292	
Total cases	2004	

Conditions involving the ear, circulatory system, accidents and genitalia tended to be rated as more severe than the average of all conditions.

The severity of the cases was homogeneously distributed among age groups as well as throughout the months of the period (July to December).

VI.A.4.f. Change or confirmation of the health aide management plan

In half the cases (categories 1 and 2) the health aide, in the opinion of the doctors, had planned, or could have planned correctly on his own judgment. Of the remaining cases, twenty percent required minor changes and thirty percent major changes. (Table VI-5)

Table VI-5 Health Aide vs Doctor Treatment

(n = 2,004)

	Number of consultations	Percentage
Confirm health aide treatment	481	30.4
Suggested treatment, but aide could have managed	331	20.9
Made minor treatment change	288	18.2
Significant change or addition to management	484	30.6
Total reported cases	1,584	100.0
Unreported	420	
Total cases	2004	

There was a direct relationship between high severity rating and suggested change in management by the physician. In the less severe cases, the health aide management was confirmed in most cases; in the more severe cases, significant or major changes were frequently suggested by the doctors. (Table VI-6)

There are obvious differences in the rate of confirmation and change among the different health aides. The rate ranged from one aide with only one case requiring change in management to another extreme example in which 63.3 percent of the cases required changes, often major ones, in the treatment. In fact, the best performance among the health aides was very close to the rate obtained by the registered nurses over the same system. (Table VI-7)

Table VI-6 Change in the Plan and Severity of the Case

	Health Aide management plan confirmation in number of episodes			
Severity Categories	Confirmed	Suggestion	Minor Change	Major Change
Low (1,2,3)	99	36	9	2
Middle (4,5)	364	281	254	448
High (6,7,8)	18	13	251	34

Table VI-7 Comparison between Registered Nurses and Health Aides in Management Plan Confirmation

(in percentages)

	Confirmed	Suggestion	Minor Change	Major Change
Mean for registered nurses	36.9	30.0	17.4	15.5
Mean for two best health aides	44.0	18.0	12.7	24.8
Mean for all health aides	30.2	20.8	18.1	30.4

VI.A.4.g. The effects on the outcome

In 70 percent of the 2,004 cases, the doctors recorded their assessment of the effect of the consultation on the outcome of the patient's problem. Criteria included effects on symptoms, well-being, and disability. In most of the judged cases (58.2 percent), a definite effect was predicted. (Table VI-8)

It is convenient to introduce here a caveat with respect to the interpretation of the predicted outcomes. It is conceivable that the value of consultation will be overrated in favor of the health provider and therefore the value of these predictions is limited. However, we consider it desirable to have some estimates of this sort.

There is a direct relation between severity of the problem and effect predicted on the outcome. Definite and marked effects were predicted for more than 75 percent of each of the four highest categories of severity, but for only 40.5 percent of the cases in the less severe categories.

TABLE VI-8 Predicted Effect of the Consultation on the Outcome
in percentages
(n = 1,398)

No effect on eventual outcome	6.8
Some effect; probably only relative to symptoms, probably not influencing future disability	34.2
Definite effect related to the future well-being or prevention of disability	58.2
Marked effect, possibly lifesaving or prevention of major disability	9.9
	100.0%

Cases with opinion recorded	1,398
Cases with no opinion on effect of outcome	606
Total cases	2,004

As might be expected, the doctors predicted a definite effect in most of the cases (77 percent) in which they suggested a major or significant change in treatment. The interesting point is that they also predicted that consultation would have a definite effect on 23 percent of the cases coded "confirmation of the health aide treatment". A plausible explanation could be that they felt the confirmation would reinforce the health aide's confidence about his own treatment plan. Data from the health aides' questionnaires showed that seven out of nine mentioned the contact with the doctor as being the reason for feeling more confident than before.

VI.A.5. Travel Authorization

It is important to provide quick transportation service to the hospital when needed. The satellite radio has provided reliable means (Ch. V) to call for that service.

But can the satellite radio system improve the accuracy of decisions about transfer, both reducing the need for transfer while not missing cases requiring transfer overlooked by the health aide? Furthermore, can it improve the benefits of the transfer by facilitating earlier discovery of symptoms and early transfer to the hospital when required?

The issue of travel authorization was considered in 9 percent of the cases. Travel was authorized to a central facility in 19 percent of these cases, or 2 percent of the total. This means there were about five authorizations per month, one urgent and four routine.

Different diagnoses have differing frequencies of travel consideration. Genitalia and breast problems, musculoskeletal and connective tissue, dental difficulties, and accidents form the categories with the highest proportion of cases considered for transfer (about 15 percent). For the five most common diagnoses the proportion of "travel consideration" is quite different, accidents and ill-defined symptoms having the higher rates. (Table VI-9)

Table VI-9 Percentage of Cases with Travel Consideration for the Five Most Common Problems

	Total Number Consultations	Percentage Considered		
		Not Authorized	Routinely Authorized	Authorized ---urgent
Accidents	157	14.0	1.9	1.9
Ill-defined symptoms	203	10.3	.5	1.0
Respiratory	356	3.7	1.4	.0
Skin	184	2.7	.0	.0
Ear	188	1.1	.0	.0

The number of travel requests per village did not seem to relate to the amount of authorized travel. For example, in some villages travel was approved in less than 7 percent of the considered cases while in another village travel requests were honored 35 percent of the time. This has been a sensitive issue. In fact, in the December 1973 meeting of the Tanana Native Health Board, a request was made that the health aide be allowed to authorize travel, and authority was granted with some guidelines and constraints.

A comparison between data about "travel consideration" and "travel authorization" shows a significant decrease between the records for the period FY 1971 and the ones for the last half of 1973. This decrease appears both in the number of considered cases, and in the number of authorized cases. However, data about hospital admissions, showing no significant differences between those two periods (Ch. VI.C.), reduce the meaningfulness of that change. In fact, the doctors at the Tanana Hospital said that reductions in travel authorizations were due to budget limitations. Such limitations could also have caused the reductions in the number of cases in which travel was considered but not authorized. Knowing the restrictive policy about authorization, the health aides would probably not consider many cases for which they would otherwise have requested authorization.

However, the fact that admissions to Tanana did not decrease suggests that a similar number of people traveled from their villages to the hospital. The doctors consulted said that even if the payment of the travel is not authorized over the radio, the people travel on their own, and once at the hospital they try to be refunded. As a matter of fact, given the financial restrictions, the doctor said that the authorizations to travel at IHS expense during 1973 were reduced to only those cases in which the patients needed to go to the hospital for clinical reasons, but were financially unable to do so.

VI.B. THE HEALTH AIDES

VI.B.1. Background

How do the health aides function in this biomedical communication system, and how does ability to communicate regularly with the doctor affect the services they provide to the villagers?

Alaskan health aides number 185 indigenous auxiliary workers, serving in 156 remote villages. In the words of a previous director of the Alaska Area Native Health Service "These community health aides, practically all of whom are of native extraction, are the true cornerstone of the health delivery system." (Wilson, 1972) They are selected, supervised and paid by their own village councils, and the Public Health Service contracts with the villages for their monthly services (monthly salary: $400-$510). They are trained in Anchorage, Bethel and Nome for a few weeks, and they continue their training in the villages, guided by visiting public health nurses. The total period of formal (not "on the job") training runs eleven weeks and is divided into four sessions. Each session is planned so that the aide will not have to be away from home and family for more than four weeks at a time. Curriculum is problem-oriented and consists of approximately fifty percent practical clinical teaching. Most aides have completed training at the third level. The aides are provided with a selection of appropriate drugs with detailed instructions. Practically all of them have in their kit an otoscope, thermometer, stethoscope, baby scale, sphygmomanometer, and hemoglobinometer. They have and use occasionally the "Health Aide Manual." Cold spots of the house serve as regrigerators. They have had (in 1972) an average of about eight years of experience on the job and their formal education on the average has been at the elementary school level. The average age in 1972 was 42 years. They tend to stay on the job as health aides for a long time and since their work and family are in the village their migration is small. This contrasts sharply with the high turnover of highly trained medical personnel in rural Alaska. The public health nurses and physicians from the hospital visit each village about ten times a year, providing ambulatory care and advisory service. (Haraldson, 1973a)

The community health aide is responsible for all health care during the long periods of time when there is no physician or nurse in the community. This responsibility includes first aid and services for acute illness and injury and care of chronic diseases. The aide may attempt to contact the Service Unit Hospital daily during scheduled medical traffic. Most aides have access only to HF radio.

As is shown later in this chapter, except for the villages that have a link through the satellite radio, contact with the doctor is not as frequent as is desirable. In the Tanana area, the health aides equipped with satellite radios contacted a doctor an average of 24 days per month, while the aides using HF radio contacted the physician only about twice a month.
Dr. Fortuine reports better performance for the HF radio system in the Bethel Service Unit. (Fortuine, 1969) The shorter distances between villages and hospital and the more southern location of the Unit probably account for that difference.

VI.B.2. Results

How did the health aides use this improved means of communication, and what are its effects on the health care provided?

A typical health aide with a satellite radio makes 309 contacts per year, including 250 patient consultations and 281 medical administrative matters. In an average month, with about twenty consultations, fourteen refer to acute problems, four to acute followups, and two to chronic management. (Table VI-4) Meanwhile, the health aide at the non-satellite villages in the Tanana region consults on only about twenty cases annually. (Table VI-1)

Information recorded by the doctors about each case shows that in half of the cases the consultation results in minor or major changes in the health aide's management plan for the patient. (Table VI-5) These data agree with the opinions given by the health aides at satellite villages. Eight out of nine said they changed treatment some of the time after the conversation with the doctor. In the non-satellite villages, the proportion of such answers was the reverse, and most said "never" when asked how often treatment is changed by radio consultation. These answers may be more a reflection of frequency of doctor contact than the content of the consultation or the aide's competence. A health aide who can never reach the doctor will never be able to change treatment as a result of talking to the doctor. (Hudson, 1972)

The doctors reported that, in their opinion, in nearly 60 percent of the cases, the consultation would have a definite effect on the outcome, related to the future well-being or prevention of disability of the patient. (Table VI-8)

It was practically impossible to get the busy health aides to fill out additional records of their activities. The following data have been gathered from the records of Bertha Moses at Allakaket, for the months of January and February 1973. As her activities fall close to the statistical mean for most of the indicators of health aide communication behavior, these data can be considered representative of the sample.

The patients discussed over satellite radio do not comprise the entire spectrum of patients managed by the health aide. The records of the "representative" health aide in a satellite village showed that in a two-month period she served about 40 percent of the village population, and that in two-thirds of the cases the patients seen were discussed with the physician during doctor-call. The records also show that in her case just one radioconsultation was enough to handle the case in three out of four individual patients.

For some kinds of situations, the health aide tended to rely more upon the consultation with the doctor, and in others, independence was the rule. Otitis media, respiratory problems and dermatological problems were the categories about which she felt it necessary to consult. On the other hand, with gastrointestinal problems, for instance, management was usually accomplished independently.

In terms of therapy, there were two distinct categories: first, those in which the health aide consulted most of the time (antimicrobials, antibiotics and sedatives); and, second, those in which autonomous function was the rule in more than two-thirds of the cases (analgesics, antihistamines, topicals).

VI.B.2.a. The importance of having the transceiver at the health aide's home: Transceiver accessibility is a factor in the frequency of radio contact with consultant physicians. Physical and psychosocial barriers may be imposed when the radio is located outside the health aide's home in locations such as the school or the community hall.

The transceivers in the satellite villages were all installed at the homes of the aides. Some of the HF radio transceivers in non-satellite villages were located outside the aide's homes, and some in their homes. It was therefore possible to make a comparison between the latter locations. This comparison of usage based on location showed that when the transceiver is located outside the health aide's home, the proportion of contacts completed is reduced by half. (Table V-2) However, the best rating for number of contacts completed for radios in the home in non-satellite villages, 42 percent of the days, is significantly smaller than the worst rating for satellite villages (64 percent). It would appear, therefore, that although location of the radio in the aide's home increases the number of completed contacts, radio reliability is still the most important factor.

VI.C. EFFECTS ON HOSPITALIZATION RATES

VI.C.1. Background

This chapter discusses the effects of improved health care communication for Alaska villages on hospitalization rates.

It is difficult to find good health status indicators for these villages concerning health care delivery or the population's health. One possible indicator is the number of native patients from the villages who are admitted as inpatients in the main hospitals serving the natives of that Service Unit, and the average length of their stay in the hospital.

VI.C.2. Methodology

A comparison of the differences in number of patients and average length of stay during the year before and the years after the satellite ground stations were installed, with those native villages in the Service Unit without satellite radios as controls, would satisfy most of the conditions of a quasi-experimental design of the form "pre-test/post-test with control group." (Campbell and Stanley, 1966, p. 13)

The villages reached by the satellite radio were not selected at random; therefore, it is possible that the satellite and non-satellite villages have dissimilar characteristics. We know, for instance, that the mean population varies from the experimental group to the control group, the latter consisting of significantly smaller villages. (Experimental group, native population mean, 139; control group, native population mean, 94.) In these analyses, the differences are assumed to have no influence over the proportion of people who go to the hospitals from each of these villages.

In the control group, all the remaining villages with predominantly native population in the Tanana Service Unit were included. (See Table VI-10 and Attachment VI.4)

The Tanana Hospital and the Anchorage Native Medical Center are the main providers of hospital care for native people in these areas. However, they are not the only hospitals used. Two hospitals at Fairbanks are often used, and some natives prefer to go to private physicians. However, we have considered the two analyzed hospitals for which data are available, Tanana Hospital and Anchorage Native Medical Center, as representative of the group for this pre-post analysis.

Table VI-10 Population of the Villages

	Total Population	Total Native Population	Average Native percent	Mean of total native population per village
Satellite Villages			95.93	139
Allakaket	174	168		
Anaktuvuk Pass	99	97		
Arctic Village	85	82		
Chalkyitsik	130	123		
Huslia	159	151		
Nulato	308	298		
Ruby	145	134		
Stevens Village	74	72		
Venetie	112	108		
Non-satellite Villages			76.06	94.2
Beaver	101	86		
Cantwell	62	43		
Circle	54	32		
Eagle	86	65		
Hughes	85	73		
Kaltag	206	193		
Koyukuk	124	121		
Minto	168	159		
Nenana	362	149		
Rampart	36	21		
	1,283	942	85.49	114.5

The data for the following analyses have been generously supplied by Theodore Vieira, Director, Office of Systems Development at the Alaska Area Native Health Service. These data refer to the patients admitted to those hospitals during the Fiscal Years 1969/70, 1971/72, and 1972/73 (FY 1970, 1972, 1973). In the original data, the cases are classified into 72 categories of primary diagnosis. We have collapsed these 72 categories into 21 groups following the code being used by the Native Health Service. (Secondary and tertiary diagnoses have not been considered.) In some of the analyses, we have grouped diagnoses: those in the first group have a clear, physiological origin and manifestation (digestive, respiratory, circulatory, etc.); a second group includes problems related to socio-behavioral events (mental disorders, results of accidents, poisoning, and violence); a third group includes all admissions related to conditions of pregnancy and delivery; and a last category, a residual one, includes the patients diagnosed as "symptoms and ill-defined conditions" and those admitted for supplemental care. (A list of categories included in each group is enclosed as Attachment VI.8.)

VI.C.3. Analysis of the Results

VI.C.3.a. Admissions: Comparing the number of patients from satellite villages admitted to both hospitals before and after the installation of satellite ground stations shows that there was no significant change and the overall trend shows stability. (Table VI-11)

Table VI-11 Patients Admitted to both Hospitals Who Reside in Satellite Villages

(all diseases)

	Before FY 1970	After FY 1972	FY 1973
Tanana Hospital	197	230	198
ANMC	58	48	78
Both Hospitals	255	278	276

The same kind of stability appears if we separate the different groups of diagnoses as described in Attachments VI.5, VI.6, and VI.7 and as shown in Table VI-12, below.

Table VI-12 Patients Admitted to both Hospitals who Reside in Satellite Villages According to Different Groups of Diseases

	Before FY 1970	After FY 1972	FY 1973
16 Categories of diseases	131	141	134
Socio-behavioral problems	57	44	55
Pregnancies	21	21	23
Ill-defined symptoms supplemental care	46	72	64
Totals	255	278	276

However, when these figures are compared with the ones corresponding to the non-satellite villages, the control group, it is clear that there are different trends influencing the groups. While the figures for satellite villages remain stable, the number of patients hospitalized in native facilities from the non-satellite group drops 42 percent from February 1972 to February 1973. (Table VI-13)

Table VI-13 Patients Admitted for All Diagnoses in both Hospitals, Residing in Satellite and Non-satellite Villages

	Before Satellite FY 1970	FY 1972	After Satellite FY 1973
Satellite villages (experimental group)	255	278	276
Non-satellite villages (control group)	185	182	109

What is the reason for that sudden drop in 1973 in the number of patients admitted to ANMC and Tanana Hospital from non-satellite villages? There is no evidence from the available data about a sudden reduction in the population of the control villages, nor about a major improvement in their health level in absolute terms nor in comparison with the group of satellite villages. Therefore, those hypotheses as possible explanations of the drop in admissions for the control group seem very unlikely. One alternative hypothesis can be suggested: Many patients in non-satellite villages could have switched to Medicare and/or Medicaid, an option for natives introduced during 1972. Directed from Juneau, these services provide free medical services for some persons with low income, the blind, the disabled, the elderly, and families with many dependents, usually through private facilities and physicians.

This hypothesis implies that the villages served by satellite radio prefer the IHS system to the private care sector, while those served by the IHS, but without the satellite link between village and hospitals, are shifting their utilization to the private sector now that financial barriers have been removed.

There is an additional indicator suggesting the viability of this hypothesis: the number of female villagers who have chosen the IHS hospital for pregnancy treatment and delivery. Table VI-14 shows these figures.

Table VI-14 Admission for Pregnancy Problems and Delivery in both Hospitals from Satellite and Non-Satellite Villages

Patients residing in	Before Satellite FY 1970	After Satellite FY 1972	 FY 1973
Satellite Villages	21	21	23
Non-satellite Villages	10	14	1

One alternative hypothesis was proposed as an explanation: the influence of the white villagers in the control group on their fellow native villagers. Whites who had previous experience with Medicare and Medicaid may have advised the natives to use them when they became eligible in mid-1972. Given that in several 'control' villages the proportion of whites is higher than in the other 'control' villages, this explanation seemed plausible. Therefore it was tested by comparing the villages with at least 30 percent white population vs. those with less than 30 percent white population, for their admission rates to the Indian Health Service Hospitals. If the "more than 70 percent native" villages had no decrease in admissions, while the "less than 70 percent native" villages had a decrease this would suggest that the preference for Medicaid and Medicare over the IHS hospital was at least sparked by the white villagers' advice or other influence. The data show that there was no demonstrable difference. The drop was equally great for both groups of villages. However, there were variations between the hospitals, with Tanana showing the greater drop.

Table VI-15 Admission to Hospital of Native Inpatients Residing in Control Villages

	Tanana Hospital			ANMC			Both Hospitals		
	'70	'72	'73	'70	'72	'73	'70	'72	'73
More than 70% native villages (Nat.pop: 92.4%) (n: 5 villages)	103	129	66	40	29	28	143	158	94
Less than 70% native villages (Nat.pop: 46.3%) (n: 4 villages)	10	11	5	25	17	10	35	28	15

As there is no evidence of differential trends in birth rates, and as both groups otherwise are similar in distance to the hospital, access to other services, Medicaid and Medicare, percentage of native population, and air transport facilities, it is possible to suggest that improved telecommunication has resulted in higher acceptability of the IHS system and preference for it, when the choice of private services is available on an equal-cost basis.

An additional hypothesis is that the villagers at the control villages could have left the service in higher proportion because they felt left out of the mainstream by not being included in the satellite network. It would be interesting to control for the behavior of villagers outside the Tanana Unit, to be able to generalize the trend detected for the control villages in the Tanana Unit. The necessary delay in obtaining that additional data prevented us from doing that analysis.

VI.C.3.b. The average length of stay: Another indicator of the possible effect of improved telecommunication on medical care was the change in the average length of stay (ALOS) of the patients at the hospital. A plausible hypothesis is that with daily access to the doctor, the cases requiring hospitalization can be detected at an earlier stage, and therefore would require shorter hospitalization. Also, ease of follow-up by radio might encourage the physician to discharge patients earlier. For this comparison, we have chosen the group of "16 categories of medical diseases" as the best indicator, because they account for 60 percent of the 16,254 hospitalization days, and for 52.5 percent of the patients reported for the three years under study.

Table VI-16 Average Length of Stay of Patients before and after at Tanana and ANMC Hospitals (in days)

	Before Satellite	After Satellite	
	FY 1970	FY 1972	FY 1973
TANANA HOSPITAL			
Satellite Villages	8.3	8.3	11.7
Non-satellite villages	6.8	10.6	13.6
ANMC			
Satellite villages	26.9	19.7	17.6
Non-satellite villages	29.2	21.4	22.7

The analysis of the data shows that the trends for each hospital differ. In the Tanana Hospital, where the less complex cases are treated, the ALOS has increased in the four year period between 1970 and 1973. At the ANMC, where the most complex cases are treated, the ALOS has been reduced. (Table VI-16) Two main reasons seem to account for these overall trends. First, in 1970 the quality of physician care at Tanana Hospital was not as high as it is at present; hence, many more cases were transferred elsewhere (e.g. to the Anchorage Native Medical Center). Second, the availability of beds at Tanana at lower cost to the IHS than contract payments to Fairbanks has resulted in long-term patients being transferred to Tanana.

It is interesting that in both cases the ALOS is lower for satellite than for non-satellite villages. Furthermore, for the satellite villages, both the increase at the Tanana Hospital was smaller, and the decrease at ANMC was greater, than the parallel comparisons for the non-satellite villages. However, it would be dangerous to infer too much from these figures, because their statistical significance is tenuous, and because there are no figures available about patients from non-satellite villages who may have left the Indian Health Service to seek care from private physicians and hospitals. It is not possible to assert confidently that the sample for 1973 is comparable to the one for 1970. For instance, the patients may seek care through private sources for their less serious ailments.

These differences appear also for the category of supplemental care and ill-defined cases (19.5 percent of the total number of patients and 11.7 percent of the total hospital days). There were no identifiable changes in the ALOS which can be related to the satellite link for the admissions due to pregnancy and delivery, nor for the socio-behavioral cases. Favorable trends that appeared in the first year, even statistically significant ones, did not hold for the fiscal year 1973, the second year after the satellite ground stations were operating.

VI.D. CONCLUSIONS

Although the data in Tables V-1--3 show dramatic increases in the frequency of contact and the number of new cases treated, they do not in themselves demonstrate improved health care. Given the small number of villages involved and the difficulty in record-keeping at the village level, it is not easy to demonstrate a statistically significant improvement in mortality or morbidity rates. Nevertheless, the data do show that health aides can consult a doctor on most days when there is a patient in need of medical attention, and that the number of cases treated by Public Health Service doctors has significantly increased. In the first-year evaluation report, the only additional supportive data were responses of doctors and health aides to a Stanford questionnaire, in which all said that they were convinced that the quality of health care had improved.

Additional data and analyses now reinforce the conclusion advanced in previous reports that health care has improved as a result of satellite radio communication. There has been an increase in supervision; health aide records show that health aides discussed two out of three of their cases with the doctor including the most complex or important ones. These resulted in increased professionalism in the diagnoses and treatment, as well as increased changes in the management plan of the patient. The absolute number of completed contacts and episodes consulted increased up to 500%. In terms of efficacy, there was an improved capacity to handle emergency cases and to solve administrative and supply requests. In terms of inferred outcomes, significant positive effects were expected as a result of the consultations. In terms of consumer acceptance, anecdotal and indirect information about patient reassurance suggest an increase in acceptance. In terms of loyalty or adherence to the system, tentative findings suggest that residents in satellite villages tend to remain in the IHS system, while residents in villages without reliable medical communication may select alternative sources of health care. Taken as a whole, this evidence supports the chain of inference that improved communication between doctor and health aide leads to improved health care.

CHAPTER VII

EVALUATION OF HEALTH AIDE EDUCATION VIA SATELLITE

VII.A. BACKGROUND

The health aides have their formal training at the ANMC in Anchorage in four one-month-long sessions. But, at least as important for their medical education, is the on-the-job training. The visiting doctors, nurses, and specialists cooperate with them and offer their knowledge to the aides.

It was considered that the daily consultation with the doctors could have an educational effect on the health aides using the satellite. They not only discuss--although briefly and in a prescriptive mode (see Recommendations, Ch. XII)--their own cases, but they also listen to the cases discussed between the other health aides and the doctor.

VII.B. METHODOLOGY

To study whether or not the radio consultation service had had a learning effect on the health aides, their performance in terms of treatment plan confirmation or modification by the doctor was compared. (Ch. VI.A.4.f) It was assumed that if the health aides who had been using the satellite radio longer had a higher confirmation-to-change rate than those who had recently started using them, given equal training and practice, the difference might be due to the knowledge they acquired listening to the doctor-call every day.

The nine health aides who had used the satellite since August 1971 were compared with the four health aides who had begun using the satellite about three months prior to the period under analysis.

VII.C. RESULTS

The results show a minor difference in favor of the more experienced aides.

TABLE VII-1 Comparison between Health Aides with Varying Experience in Satellite Radio Usage (in percentages) for period July - December 1973

	Doctor's Response to Health Aide Management Plan			
	Confirmation	Suggestion	Minor Change	Major Change
More experienced health aides (since August 1971)	29.9	20.4	17.8	31.9
Less experienced health aides (since April 1973)	25.0	20.0	21.3	33.8

Number of Cases = 1,574

Unreported = 430

Total = 2,004

It is possible to suggest that in the first few months the health aides who listened to one daily hour of medical communication quickly reached a plateau after which incremental learning was slight. Since this part of the evaluation did not begin until three months after installation in the four new sites, an early, more apparent difference may have been missed.

The answers to the questionnaires for health aides (Hudson, 1972) gave additional information about learning. While six of the nine health aides using satellite radio could name something specific they had learned from listening to medical traffic, none of the aides from the non-satellite villages could think of anything they had learned. Among the examples given from the satellite villages were:

> "If otitis media has not stopped draining at 7 days, the antibiotics should be continued and not stopped; also cortisporin should be continued."

> "Penicillin is wasted for colds. Triple sulfa may cause kidney stones if people don't take lots of water."

A health aide commented: "I learn a lot from listening to other health aides report things. I try to answer it myself and see if I am right."

CHAPTER VIII

EVALUATION OF DOCTOR-TO-DOCTOR CONSULTATION BY SATELLITE

VIII.A. THE ST. PAUL-ANCHORAGE LINK

St. Paul and St. George, the main Pribilof Islands (1970 population 613, of which 584 are natives), are located in the Bering Sea between the Bering Strait and the Aleutians, about 300 miles west of the Alaska mainland. The doctor lives on St. Paul, the larger of the two islands. St. George Island, 40 miles away, is staffed by one registered nurse. Transportation between the two is via Government supply ship four times a year, or by charter aircraft, weather permitting. HF radio links the islands.

The 613 inhabitants of St. Paul and St. George Islands in the Bering Sea are served by one physician. The ATS-1 satellite now links this physician to the Alaska Native Medical Center in Anchorage. The satellite channel is available on a daily basis for consultation between the physician and his specialist colleagues, and for administration and travel requests.

In this section data are analyzed to assess the value to the islanders of this service which provides direct access to the medical talent centralized 800 miles away in a large regional referral center.

The evaluation focuses on three topics:

1. Reliability of the service: Is it possible to contact the specialist soon enough to make a difference to the case and as frequently as the case requires?

2. Capacity of the service: Is it possible to transfer all the necessary information within the limitations of the channel?
3. Utility of the service: Does the communication make a difference in the treatment and outcome of the case?

The data show that the satellite link is providing reliable communication with sufficient capacity to handle the information required by the remote doctor for most patient problems, and that this service is significantly affecting their care and treatment.

The following is a summary of the findings which are analyzed in detail in the forthcoming sections.

The communication link was used on two-thirds of the days in the period under analysis.

All contact had signal quality ranked in the two top categories for both strength and intelligibility.

In an average month there were six patient consultations and about fifty administrative exchanges.

The average time elapsed in a patient consultation was six minutes, and three minutes for each administrative matter.

The annual rate of consultation is about 130 per thousand population.

Most of the consultations referred to moderately severe problems, with potential of deterioration to disability or mortality. The cases were moderately urgent, but not urgent enough to make a delay of a few days to one week in the consultation result in "predicted significant deterioration."

- Treatment and diagnosis were the most common primary purposes of consultation with patient motivation and reassurances being almost insignificant, but M.D. reassurance was also considered significant in half of the cases.
- Transfer of the patient and/or change or institution of treatment were the typical results of the consultation.
- In all but one case for which the remote doctor suggested a transfer, his opinion was confirmed by the consultant. In several other cases, the consultant suggested a transfer, although the remote physician previously had not thought it necessary.
- In the doctors' opinions, in most cases neither facsimile, EKG, nor audiovisual transmission would have materially improved the consultation. In 20 percent of the instances the consultant thought the latter feature would probably have been valuable.
- The consultant doctors rated the value of the contact as being moderately to very valuable in the management of the specific patient, while the doctor at St. Paul tended to be slightly more conservative in his ratings.
- There was a similar discrepancy between the remote physician and the consultants on the effect of the consultation on the predicted outcome. The consultants asserted that in most cases the consultation would have a definite effect relating to future well being or prevention of disability, while the St. Paul doctor recognized some effect, but was more skeptical.

VIII.B. METHODOLOGY OF ANALYSIS

The two basic sources of information used in this analysis were the logs of the Minitrack station at College containing data about daily contacts, signal quality, message content and time elapsed, and the responses to questionnaires filled out by both the doctor on St. Paul and the consultants at the ANMC.

The Minitrack log analysis covers the period between February and December 1973. The questionnaires were filled out between August and December 1973. During this latter period there were thirty teleconsultations between St. Paul and Anchorage. Copies of the St. Paul doctor's questionnaire and the ANMC consultants' questionnaire are Attachments VIII.1 and VIII.2. The consultants reported on 29 consultations and the St. Paul doctor on 17. Together they covered all thirty teleconsultations for that period.

VIII.C. ANALYSIS OF THE RESULTS

VIII.C.1. The Exchanges

There was radio contact between the doctor at St. Paul and the consultants at the ANMC on roughly two-thirds of the days in the reported period from February to December 1973 (186 out of 307). Practically all the contacts had a signal quality ranked in the two top categories on a scale of five for both strength and intelligibility. There was an average of six patient consultations per month, each one about six minutes long. A typical month also had 53 administrative exchanges (about two per day), for a duration of nearly three minutes each.

Compared to the Tanana Village health aide-to-doctor exchanges, the doctor-to-doctor exchanges were less frequent, twice as long, and concerned a smaller proportion of cases.

Table VIII-1 Comparison between Aide-to-Doctor and Doctor-to-Doctor Exchanges

	Aide-to-Doctor	Doctor-to-Doctor
Annual patient radio consultation per capita	2.0	0.13
Minutes per contact	4	12
Minutes per patient consultation	3	6
Minutes per administrative matter discussed	1	3

The smaller number of cases and the longer time in the doctor-to-doctor exchanges probably reflect the fact that the doctor needed to consult on only his most complex cases, and that his administrative requests required a more detailed interaction, especially because most of them dealt with the building of the new clinic.

VIII.C.2. Description of the Cases Consulted

A wide range of problems was covered by the consultations (list of diagnoses attached as Attachment VIII.3). The doctors rated cases in terms of severity of the problem, urgency and purpose. All thirty consultations during the period are included in the analysis.

VIII.C.2.a. Severity: On a five-point scale describing severity of the symptoms and the potential for deterioration and mortality, both the consultants (in 55 percent of the cases) and the St. Paul doctor (in 35 percent of the cases) marked the middle category more times than any other.

About 10 percent of the cases were considered severe problems of life-threatening proportions, and about five percent were a simple question.

The cases of greatest severity were diagnosed as carcinoma of the colon-rectum, a coma of unknown etiology, pancreatitis, and a perforated ulcer. In the next most severe category they coded ischemic heart disease, a ruptured ocular globe, and a gastrointestinal hemorrhage. (Table VIII-2)

VIII.C.2.b. Urgency of the cases: A delay of just one day in 15 percent of the cases would have meant substantial risk to the patient in the doctor's opinion. For another 45 percent of the cases, a delay of a few days might have resulted in significant worsening, and for the remaining 40 percent, the reports indicated that a delay of one week would not have affected the outcome. In summary, 85 percent of the cases could have been delayed at least two or three days with no significant risk.

Considering the proportion of days contacted and the estimate that in only 15 percent of the cases (Table VIII-3) a delay of up to a day would have meant a substantial risk to the patient, it can be asserted that in nearly all cases consultation was obtained as soon as it was required.

However, in one case (out of thirty) the remote doctor had to use an HF radio to consult about a perforated gastric ulcer. This was the only case of a critical emergency in the whole period. That particular transmission was on a Saturday, when there is normally no satellite consultation with ANMC. The quality of the HF radio transmission was very poor.

VIII.C.3. The Content of the Radioconsultations

VIII.C.3.a. Methodology

In August 1973, new forms were introduced to enable more elaborate evaluation of the doctor-to-doctor exchanges (see Attachments VIII.1 and VIII.2). For each consultation, both the doctor at St. Paul and the consultant physician at ANMC had to describe or evaluate the severity of the case, its urgency, the purposes of the consultation, and its result in terms of suggestions, management of the patient, and predicted effect on the outcome.

VIII.C.3.b. Analysis of the results

During the five months reported (August to December) there were thirty patient consultations evaluated by either one doctor or both. About half of them (16) were evaluated by both doctors, allowing a contrast of their opinions as an indicator of the reliability of the data, and a comparison of their different perspectives.

In that five-month period, the isolated doctor on St. Paul needed to consult about topics in general medicine in one-third of the cases. Seven other specialties accounted for the other two-thirds (surgery, orthopedics, pediatrics, mental health, obstetrics-gynecology, otolaryngology, and ophthalmology). Eighteen different specialists from ANMC were his consultants.

Table VIII-2 Severity of Cases Requiring Teleconsultation

According to	St. Paul Doctor n = 17	Consultant n = 29
1. A simple question about an essentially asymptomatic individual, i.e., about medication, preventive management, such as immunization or the use of a household remedy.	1	1
2. Evaluation of a minor but symptomatic problem relating to a particular organ system, for instance URI or urinary tract infection with little potential to become a severe problem and little potential for mortality.	4	4
3. Evaluation of a moderately severe problem with potential for deterioration to a severe problem or to disability or chronic disease with moderate potential for mortality.	6	16
4. Evaluation of a problem producing severe symptoms or potential disability or a chronic process with a high potential for mortality.	5	4
5. Evaluation of a severe problem of life-threatening proportions	1	4

Table VIII-3 Urgency of the Cases Consulted

Urgency of the consultation according to:	St. Paul n = 17	Doctor/Consultant n = 29
1. Not at all urgent--delay of one week would not affect outcome re: health status	5	14
2. Some urgency--delay of a few days might result in significant worsening	8	11
3. Urgent--a delay of 24 hours would have meant substantial risk to patient	2	2
4. True emergency existed	1	1
5. No response	1	1

VIII.C.4. Purpose of the Consultation

"Treatment" (100 percent of cases) and "diagnosis" (75 percent of cases) were the most frequent primary purposes, or "also significant" purposes mentioned by both the consultants and the St. Paul doctor. "Preventive management" was also often rated as a primary purpose.

On the other hand, patient reassurance, and patient motivation were in most cases considered to be of little or no significance. (The St. Paul doctor rated 76 percent and 65 percent of the cases in these two categories, respectively.)

VIII.C.5. The Doctors' Evaluations of the Radioconsultation

Three main questions about the value of the consultation in terms of management of the patient, objective results (such as changes, suggestions, transfer), and effects on the predicted outcome were asked.

Both the consultants and the St. Paul doctor agreed on the objective results, but the consultants tended to rate higher both the value of the contact for the management of the specific patient and its effects on predicted outcomes.

VIII.C.5.a. Objective results for management

Transfer of the patient (arranged or suggested) was the most common result of the contact, occurring in about half of the cases. Modification of the treatment was the effect in about one-third of them; no changes in management, or merely suggestions about diagnostic studies occurred in the remainder; the remote doctor expressed his feeling that even in these cases the consultation was reassuring.

Table VIII-4 Objective Results of the Consultation for Management

Results of consultation*according to:	St. Paul Doctor/ n = 17	Consultant n = 19
No change in management recommended	4	4
Diagnostic studies suggested	3	9
Change or institution of treatment	5	10
Transfer arranged or suggested	9	12

*More than one category was checked for some consultations

VIII.C.5.b. Subjective evaluation of the consultation in terms of management

The consultants tended to rate the value of the contact in management of the patient higher than did the St. Paul doctor. The consultants rated practically all the cases "very valuable" or "moderately valuable" while the St. Paul doctor gave lower ratings. In fact, for about half the cases, he stated they were of minimal value. However, in more than two-thirds of the cases change of location or of treatment resulted from the consultations. Only further study could assess which opinion, the consultant's or the remote physician's, is more accurate.

VIII.C.5.c. Effects on predicted outcome

Again, the consultants were more favorable in their predictions, stating that the consultations should have "a definite effect relating to the future well-being or prevention of disability" in 48 percent of the cases, and "some effect probably only relative to symptoms, probably not influencing future disability" in only 27 percent. Ten percent of the cases were placed in each of the extreme categories of "no effect on eventual outcome" and "marked effect possibly life-saving or prevention of major disability" by both doctors. Cases of angina, metabolic coma, hyperventilation, and a perforated gastric ulcer were those in which the consultants predicted a marked major effect. Out of the 16 cases rated by both doctors, seven were rated identically. In eight the consultants predicted a greater effect than did the remote doctor.

TABLE VIII-5 Effects on Predicted Outcomes

According to:	St. Paul Doctor (n = 17)	Consultant (n = 29)
No effect on eventual outcome	1	3
Some effect probably only relative to symptoms; probably not influencing future disability	10	8
Definite effect relating to future well-being or prevention of disability	4	14
Marked effect possibly life-saving or prevention of major disability	1	4
No response	1	-

VIII.C.5.d. The need for additional communication capabilities

Satellites are technically capable of offering more than voice transmission for medical teleconsultation (e.g., facsimile, ECG and video transmission). But are those additional features considered beneficial by the doctors?

It is hard to generalize about the convenience of hypothetical features, and in this sense the following statements by the consultants and the St. Paul doctor are less relevant than the opinions of those who have actually used the features. On the other hand, the professionalism of the respondents and their agreement on responses give validity to their answers.

In about two-thirds of the cases both the consultants and the St. Paul doctor considered that neither facsimile transmission, ECG and/or other physiological parameters, nor audiovisual transmission would have "materially improved the consultations". In most of the remaining cases (20 percent of the total) the consultants considered that slow-scan TV one-way to Anchorage would have done so. The St. Paul doctor, a hypothetical sender but not receiver of the visual information, considered it valuable in only 12 percent of the cases. In other words, he rated his own ability to describe the case fully in words higher than did the consultants.

In the only true emergency (a perforated gastric ulcer), the consultant strongly asserted that a better audio transmission would have facilitated the management of this patient, but an audiovisual transmission would have been ideal. (This consultation was accomplished via an HF radio.)

VIII.C.5.e. Differences in the perspective between the remote doctor and the consultant

Both the consultants and the St. Paul doctor completed questionnaires on sixteen of the thirty cases requiring teleconsultation during this period. Part of the remote doctor questionnaire was designed to be filled out prior to the contact and part to be filled afterwards.

A comparison of the sixteen cases rated by both doctors shows that their evaluations and opinions tend to be similar in about half of the cases for each category. For the other half, in the three more objective categories--severity, urgency, and changes in management--their discrepancies tend to balance each other, but for the more subjective categories of effects on predicted outcome, and value of this contact, the consultants were much more optimistic about effects of teleconsultation.

Table VIII-6 Comparisons between St. Paul Doctor and Consultant

Rating on	Agreement	St. Paul Doctor higher	Consultant higher	Missing data
Case description				
Severity	6	6	4	-
Urgency	7	4	3	2
Effects of the teleconsultation on:				
Changes in management	12	2	2	-
Predicted outcome	7	1	8	-
Value of the contact	5	1	9	1

In terms of the agreement about which additional feature would have been valuable, in eight cases (50 percent of the ones rated by both) both doctors agreed that none would have materially improved the consultation; in seven cases they considered different features valuable, and in only one case did they agree: Both felt that audiovisual transmission would have improved consultation for a fractured tibia.

TABLE VIII-7 Need for Additional Communication Features

Consultation would have been materially improved by addition of:	According to St. Paul Doctor	According to Consultant
Facsimile transmission	2	2
ECG or other physiological parameters	1	3
Audiovisual transmission (slowscan TV one-way to Anchorage)	2	6
None of them	12	19

VIII.C.6. Air Transfer of Patients

The cost of air travel, especially on chartered flights, and its vital significance to health care, make it highly important to analyze any mechanism which could improve decision-making about air transfer.

The Pribilof Islands are served by one flight a week. One-way fare to Anchorage is $338. Chartering a flight would probably cost four to five times as much.

In the doctor-to-doctor call the subject of possible transfer appeared in many cases. Comparison between the St. Paul doctor's prediction about need to transfer prior to contact, and the opinion of the consultant during the communication, serves to measure the value of this link both in saving unnecessary trips and assuring necessary transfers.

In eleven of the thirty reported cases this subject arose. In five of them the remote doctor's opinion differed from the consultants. Of those five, four transfers were suggested or arranged that were not previously considered necessary by the St.

Paul doctor. The fifth case was previously rated as "non-urgent transfer necessary," but the consultation avoided that transfer.

In six other cases, the remote doctor's recommendation of patient transfer was confirmed by the consultants. Of these, only one was urgent.

Based on these data, one might conclude that available radio consultation backup to a remote physician might increase the number of evacuated patients. Indeed, in four instances transfer plans were initiated by the consultant when the primary physician had not felt that transfer was necessary. In only one instance did the opposite occur, i.e., the consultant recommended that the patient not be evacuated when the primary doctor favored evacuation.

Unfortunately, with the small number, general conclusions are not warranted. Indeed, the appropriateness of the transfer would be a measure of the effectiveness of the interaction. An in-depth analysis of such transferred (and not transferred) patients by an impartial referee might be a more satisfactory approach to this issue. This would require an analysis of the issues on which the decision to transfer was made and an evaluation of these issues based on the findings at ANMC after the patient was fully evaluated, and was not attempted in this evaluation.

VIII.D. DISCUSSION OF THE RESULTS

Is it possible to generalize the results obtained from the St. Paul-Anchorage doctor-to-doctor exchange to other cases? What are their limitations? A short discussion will clarify both their predictive power for other cases and the sources of their limitations.

There are two factors which can limit the validity of this experiment: the fact that only one doctor was the advisee, and the specific health conditions of the Pribilof Islanders.

Only one doctor was the advisee, originator and principal performer of the consultation. He was aware of the goals of the experiment. Other doctors in his situation, because of personality, background or experience, might be more or less willing to consult with specialists, might use different amounts of time for consultation, or might be more or less interested in using ECG or audiovisual features in the exchange, etc. In an ideal experiment, a group of remote doctors would have access to consultants. This was the format of the health aide-to-doctor exchanges in the Tanana region, with about twenty remote health aides having access to a doctor. They provided a range of personal characteristics, background and experience as medical communicators. Therefore, the health aide figures are probably more representative (see range of variation in Ch. VI.A).

However, several arguments can be made for the validity of the results in the doctor-to-doctor experiment. First, the medical profession has standardized training and a standard vocabulary for discussing cases. Second, the communication behavior of the St. Paul doctor is constrained by the consultants. It is not solely a result of his individual pattern and impulses. In the period under analysis, for instance, he had to interact with eighteen different colleagues from eight different specialties. Therefore, the effects of his own characteristics were probably moderated by his interaction with the large variety of different consultants.

A second restriction on the generality of the data stems from the possibility that the health and sanitation conditions of the Pribilof Islanders are different from those in other areas to which the data can be applied. This aspect should be analyzed in each particular case.

It should also be stated that the remote doctor felt that "the interaction is limited by the fact that the conversation is monitored by many people."

CHAPTER IX

EVALUATION OF NURSE EDUCATION VIA SATELLITE

by Virginia Hunn Fowkes

IX.A. NEEDS AND DESCRIPTION OF THE COURSE

A Coronary Care course in nursing which commenced September 27, 1973 and ended January 24, 1974 was given via ATS-1 radio. The University of Alaska Continuing Education offered participating students three academic credits. (See Attachment IX.1 for Course Description.)

The Coronary Care course was selected to be given via the satellite for several reasons. First, it is a well-established curriculum that could easily be implemented. Second, the native health hospitals in outlying Alaskan villages have equipment which can be used for sophisticated cardiac monitoring of patients. This equipment includes a cardiac monitor, defibrillator and pacemaker component. This equipment had been used relatively little in patient care mainly because the nurses were not familiar with its use. Although the numbers of patients with coronary heart disease are limited and therefore traditional coronary care does not occur, this equipment can be used for a variety of medical and surgical patient care needs. Therefore, it was felt that this particular course would provide nurses and other health personnel in remote areas with the knowledge necessary to use this equipment in providing more sophisticated patient surveillance as well as improving patient care generally. Additionally, nurses in these isolated areas had expressed needs for continuing education, particularly with the impending new licensure regulations that will require these individuals to have a certain amount of continuing education credit each year in order to maintain their licensure. (See Attachment IX.2 for Objectives of Course.)

Traditionally, Coronary Care courses such as this are given through a Community College program or a hospital based in-service program. Regardless of the setting, the curriculum is fairly well standardized and similar to that outlined in Attachment IX.3. Therefore, the only major difference between this curriculum and other courses is that it was given via satellite radio. The course coordinator, Ms. Betsy Ovitt, presented all of the sessions except two. The session on congenital defects was given by a local physician and the session on the respiratory system was given from Stanford by Ms. Jacqueline Wade and Ms. Virginia Fowkes. The lectures were held each Thursday evening and were two hours in length. There were breaks every thirty minutes during which time each hospital station was called and there was an opportunity for interaction between the instructor and students. A syllabus for the course was sent to each student in advance of the program. In addition, visual aids and hand-outs were sent to the students prior to each session so that they might follow along with the instructor appropriately. Publicity for the course was arranged through the University of Alaska Continuing Education and the course was open to registered nurses, licensed practical nurses, medics, physician's assistants or other health workers.

Twenty-five students registered for the course initially. They were located at the following stations:

Barrow	6	Galena	1
Nome	6	Fort Yukon	2
Kotzebue	5	Juneau	5

All of the towns listed with the exception of Fort Yukon and Galena have hospitals and the aforementioned equipment. Other individuals in other communities listened in as well but did not participate for credit. Of the 25 enrolled students, 16 completed the course, 18 submitted the biographical questionnaires, and 15 submitted the final evaluation questionnaires.

Table IX-1 shows the results of the biographical questionnaires which were received.

TABLE IX-1 Characteristics of Students

Place of residence	Number of students
Nome	5
Barrow	6
Kotzebue	1
A.P.O.	1
Juneau	3
Auke Bay	2
Education	
In states other than Alaska	16
Scotland	1
Canada	1
3-yr R.N. diploma program	14
2-yr R.N. associate program	2
4-yr R.N. baccalaureate program	1
Medic	1
Previous college	8
Present job position	
General duty	11
Alcohol rehabilitation	1
Anesthesia	1
Clinic	1
Clerk	1
Emergency room	1
Director of nurses	1
Not working	1
Previous work experience	
One year	1
Two years	2
Three years	3
Four years or longer	11

(continued)

TABLE IX-1 (continued)   Characteristics of Students

Type of work experience	Number of students
Medical-surgical	12
Intensive care units	2
Emergency Room	3
Operating room and anesthesia	3
Obstetrics	3
Pediatrics	2
Public health	1
Administration	1
Reasons for taking course	
Knowledge about heart disease	8
Knowledge about EKG, arrhythmias	6
Continuing education credit	5
Previous exposure to a	
Coronary care course	6

Of particular note is the following: that all 18 of the students completing questionnaires received their formal education outside of Alaska. Seventeen of the responding students are R.N's and most of those are from 3-year R.N. diploma programs. Secondly, none of the students enrolled is presently practicing in coronary care units, and finally, in addition to taking the course for upgrading knowledge, a number expressed interest in the continuing education credit. Also, six have previously been exposed to the course material.

On October 17 and 18, 1973 during an evaluation staff visit, a lecture session was observed. Though none of the students had seen the course instructor, Ms. Ovitt, there was obvious, comfortable rapport between the students and instructor. The students at each of the stations seemed quite free in interacting with her regarding questions about the material and other comments. Although interrupted for emergency communications, a similar program which was broadcast from the transmission facilities operated by Dr. Aldo Da Rosa and Stan Hall at Stanford proceeded equally smoothly. Again, the students interacted comfortably with the instructors.

Also during the visit, plans for the evaluation were formulated. Dr. Richard Lyons, the WAMI director, and Betsy Ovitt, the coordinator, welcomed the consultation and were more than cooperative in helping to plan and implement the evaluation project. In addition, the cooperation of Ms. Nancy White, the nursing coordinator with Washington/Alaska Regional Medical Programs, was solicited. Ms. White has traveled extensively in the participating Alaskan communities and has had experience coordinating similar courses through RMP in the state of Washington. Furthermore, Ms. White made available computer processing of testing materials, the testing materials themselves, and comparisons with similar community groups. Both Dr. Lyons and Ms. White expressed concern regarding the transiency of nurses in the participating Alaskan communities. As noted in Table IX-1, none of the nurses are natives and turnover is high in these communities. Ms. White indicated further that all of the nurses are involved with patients and "in highly responsible and critical areas of nursing." She further felt that this type of continuing education was essential and would have impact on patient care---even though coronary heart disease is not a primary health problem in the native villages.

IX.B. EVALUATION OF THE COURSE

For purposes of evaluating the satellite communications media, the students enrolled in the course took fairly well standardized pre- and post-tests. The tests have been used extensively by Washington/Alaska Regional Medical Programs for coronary care activities. (See Attachment IX.4 for Description of Test and Standards). Computer printouts were obtained for all scores. Scores from the Alaska group were then compared with scores from two different groups taking a similar and traditional educational course at Bellevue Community College in Washington. Bellevue is a community college located a few miles east of Seattle in a new high-density populated area. The nurses enrolled were comparable to the Alaska group in that most of them did not have coronary care units in their hospitals and not all had monitoring equipment. For the most part, these R.N.s had had some exposure to coronary care education prior to the course. Some were R.N.s taking a refresher course who had little or no contact with monitors and practiced in rural community hospital settings similar to those that the Alaskan students relate to.

Table IX-2 summarizes the results of this comparison. It is of note that the Alaska group performed similarly to the two groups from Bellevue on both pre- and post-tests. An approximate 20 percent rate of improvement is noted in all three groups between pre- and post-test performance.

The Alaska group was somewhat higher than the regional mean for the pre-test which is 32 percent and also for the post-test which is 53 percent. However, this was the result of a broad range of scores from 24 to 80 in the pre-test and 52 to 84 in the post-test. Assessment of individual scores indicated that all students with the exception of two improved their total scores and most of the part scores on the post-test. (The two that did not, dropped from 80 to 78 and 55 to 53.)

For purposes of subjective evaluation, the students were asked to complete a questionnaire. Fifteen of the sixteen students who finished the course completed the questionnaire. Tabulation of the student responses to the questionnaire is detailed in Attachment IX.5. Generally, the students found the course content and materials to be valuable. Most indicated that there was difficulty with the radio transmission which varied in frequency and location.

TABLE IX-2

Pre-Test

Number of Examinees --- Alaska-23
Number of Examinees --- Bellevue I-30
Number of Examinees --- Bellevue II-29

Part Score	Alaska Mean	Bellevue I	Bellevue II	Alaska Std. Dev.	Bellevue I	Bellevue II
CCU Concepts	10.78	(12.43)	(11.28)	4.16	(3.24)	(2.80)
Complications	5.61	(7.20)	(5.03)	2.39	(2.12)	(2.59)
EKG/Arrhythmias	11.39	(15.03)	(12.52)	4.75	(4.48)	(4.89)
Chem. Therapy	5.57	(5.90)	(5.10)	2.41	(2.29)	(1.84)
Other	8.65	(10.07)	(9.48)	3.06	(2.59)	(3.06)
Total Score	42.00	(50.63)	(44.41)	14.00	(11.24)	(11.96)

Post-Test

Number of Examinees --- Alaska-16
Number of Examinees --- Bellevue I-28
Number of Examinees --- Bellevue II-21

Part Score	Alaska Mean	Bellevue I	Bellevue II	Alaska- Std. Dev.	Bellevue I	Bellevue II
CCU Concepts	17.25	(19.04)	(18,67)	3.03	(2.38)	(2.51)
Complications	8.81	(9.00)	(8.81)	1.51	(1.77)	(1.79)
EKG/Arrhythmias	17.37	(19.54)	(17.71)	2.18	(2.18)	(3.40)
Chem. Therapy	9.00	(9.71)	(9.57)	1.90	(1.94)	(1.53)
Other	11.88	(14.68)	(14.71)	2.71	(1.77)	(2.21)
Total Score	64.31	(71.96)	(69.48)	7.79	(7.58)	(8.76)

Most felt there were advantages to the course, particularly the continuing education credit. Generally, the disadvantages stated related to the impersonal approach. Fourteen indicated that they would definitely take another satellite radio course, suggested a broad range of topics, and felt there would be advantages to video transmission. (Refer to last section of Attachment IX.5 for detail of responses.)

IX.C. CONCLUSIONS AND RECOMMENDATIONS

The results of the testing indicate that learning took place. Further, the performance levels on pre- and post-tests and the rate of increase in performance between pre- and post-tests were comparable to those of Bellevue Community College where similar courses were given in the traditional classroom setting. This suggests that the satellite communications medium is an effective way of providing education to remote areas. Although periodically there were transmission problems, they did not affect the desired outcome of performance.

The nurses' own evaluations indicate enthusiasm about the course and a desire for additional programs.

The impact of a course such as this on patient care is more difficult to determine, but is, of course, the ultimate concern of health educators. Often courses such as this one which are given within community colleges or even within hospitals do not have a correlated clinical practicum where the instructor can observe and/or help the student directly apply the knowledge to patient care. However, if this cannot be arranged during a course (and this would be difficult in Alaska) it is important as follow-up. Therefore, it would seem imperative in future programming that the instructor who gives the satellite radio session travel to the individual communities and work with the students in their respective clinical settings. Only in this way can the learning objective be insured and the impact on patient care be assessed.

It is suggested that future programs which may be given via satellite radio be focused on more relevant native health problems.

Finally, although this was not addressed in this study, there seems little evidence to suggest that nursing personnel given more continuing education will remain for longer periods of time in these communities. Certainly, it is necessary to provide training in order to update information and skills of health providers in remote areas. However, for long-term goals, it would seem more cost-effective to educate native peoples who come from these areas and to provide incentives for them to remain there.

CHAPTER X

ASSESSMENT OF SOCIOLOGICAL IMPACT OF RELIABLE TELECOMMUNICATIONS FOR BUSH ALASKA

During the operation of the satellite radio communication experiment, the health care exchanges occupied only a part of the hours of the day in which the satellite was available. The characteristics of two-way radio and teleconferencing capability of the communication network allowed a series of very special programs. From educational ones with possibilities for interaction between participants, to entertainment and story telling, a wide range of experiences went over the air in the non-medical time. The impact of those programs and the possibilities of the system in terms of education, decision-making conferences, discussion among colleagues (librarians, teachers, medical personnel, etc.), and interactive entertainment were not within the scope of this evaluation.

However, we have detected several effects which can have a positive effect on the living conditions of the Native people in those remote villages:

X.A COMMUNICATION BETWEEN HOSPITALIZED PATIENT AND FAMILY AT THE VILLAGE

The satellite link gives the families the chance to get news about patients at the hospital much more easily than over the previous HF system. One illustrative comment: "Last year (before satellite) we didn't know if they were dead, still in hospital, or what". (Hudson, 1972)

The importance of this contact for the villagers must be emphasized. In the opinion of the health aides, the doctors, and native representatives, it has a significantly positive effect on the well being of the isolated villagers. It may be that the greater loyalty and acceptance of the Public Health Service in the satellite villages suggested in Chapter VI.C is partly due to the availability of regular news from the patients at the distant hospital. It is also possible that the ability to contact the patient at the hospital will reduce one of the reasons for the migration to the urban centers, for accessibility to the medical centers.

X.B. INCREASED CONTROL BY THE NATIVES OVER COMMUNICATION

The increased number of contacts due to the fact that the transceivers are located at the health aides' homes (Ch. V.F.), has added to the reliability of the system and increased the importance of the health aide in the village. This person, a Native selected and paid by the village council, is in charge of and controls the access at the village end to this virtually exclusive linkage with the external world. This contrasts with the regular pattern of services controlled by non-Native persons and may have a positive effect on the self-assurance of the Natives. Of course, this is only one area of services and other changes are required for a more complete effect in that sense.

X.C. REASSURANCE OF THE HEALTH AIDE AND THE PATIENTS

The attitude of the health aide towards the satellite radio is not only a crucial factor in the operation of the system, but also an additional indicator of its effectiveness compared to the previous HF equipment. In mid-1972, about a year after the installation of the satellite ground stations, a questionnaire was administered to the nine health aides in the satellite villages and to five health aides in non-satellite villages. The results are fully presented in a vivid report of that survey. (Hudson, 1972) Some of those findings need emphasis and further discussion relative to more recent data.

The answers of the health aides at the satellite villages, in contrast to those at villages supplied with HF radio, show that the former had no difficulty at any time understanding the instructions of the doctor received over the satellite radio, while the latter mentioned that the quality of the signal was a problem once in a while. The HF radio often faded in and out, was noisy, and was very difficult to hear. Users often had to repeat With improved telecommunication, it is more frequently possible to consult with the doctor before beginning treatment. This difference is especially important given the high number of changes in the health aide's management plan which result from consultation. (Table VI-4) Frequent communication with the doctor seems to increase the health aides' ability to persuade the patients to follow their advice. Since patients may listen to the radio discussions during consultation between aide and doctor, the aide may use the doctor's advice in reinforcing her suggestions about self-administered medicines or treatments which she does not feel are appropriate. She may encourage the patient to listen in if she feels this may increase compliance or reassure the patient.

The opportunity offered by the satellite to listen to more exchanges between other health aides and the doctor appears to be very important both for morale and for continued learning, in the opinion of the health aides.

After working with the satellite radio for about a year, the majority of the health aides felt much more confident in their work. There was one exception to this, however; one aide felt less confident, because she was only useful to report to the doctor.

In the chapter of Recommendations (Chapter XII), some suggestions for changes in the mode of operation are advanced, both to reduce that possible sense of dependency and to increase learning, and therefore to improve health care.

CHAPTER XI

EVALUATING FUTURE COMMUNICATIONS SYSTEMS

(by Dr. Bruce Lusignan and Dr. Michael Sites)

As part of the NIH contract, future systems to provide health communications services to Alaskan villages were assessed. This activity took a number of forms summarized briefly in this chapter and expanded upon in the attachments. The results are presented as a chronological series of analyses or tests that have led to specific recommendations.

XI.A. SELECTION OF SATELLITE LINK

--It is recommended that the Canadian satellite, Anik II, form the basis of the initial Alaskan Indian Health Service communications system.

This study was concerned with operational services only, not experimental. Therefore, the only satellites considered were commercial ones that can be counted on to provide continuing services. Those considered included the international satellite, Intelsat IV, and the Canadian satellite, Anik II. Both of these satellites are in operation today. The systems each have a primary and a standby satellite in orbit and another ready to be launched in case of difficulties with either of the first two. A third commercial satellite, "Westar," a United States domestic system operated by Western Union, was considered but rejected because its antenna patterns do not adequately cover Alaska.

Technically, Intelsat IV and Anik II are comparable for Alaskan intrastate voice communications (Attachment XI.1). From a business sense, however, Anik was favored. Intelsat IV would require use of a special high-gain antenna pointed in Alaska's direction, and Alaska would have to absorb the cost of a full satellite transponder even though intrastate communications would require only a fraction of the capacity. On the other hand, Anik II's antenna covers Alaska, Canada, and about 2/3 of the lower 48 states. RCA Globcom has rented transponders on the satellite and a portion of the transponder can be rented for Alaskan intrastate use. (Though transponder rental prices vary with competition, latest estimates indicate the Intelsat IV transponder price with high-gain antenna to be twice that of the Anik II transponder, another point in favor of Anik.)

XI.B. SELECTION OF STATION CONFIGURATION

--A computer optimization program identified a small station configuration (10-ft. diameter antenna) as least costly for Alaskan rural voice communications.

With the satellite chosen, there are still many system choices that must be made to ensure lowest cost for the given service. The choices are complex, involving many technical and economic factors that interact in sophisticated ways. To handle these factors, Stanford, under NASA Grant 05-020-659, has developed a comprehensive computer based program (Attachment XI.2). This program is specifically designed to use only commercially available equipment. Thus, it identifies solutions that can be readily implemented. A comprehensive and computerized demographic description of Alaska was also developed as a part of the current evaluation contract. This demographic file contains information of the distribution of population and communication facilities, as well as other subjects. A report on the computerized demographic file is included as Attachment XI.3.

The requirements of a generalized voice communications network serving an area the size of that covered by Anik or by the proposed RCA satellite were given to the program. From this input, the optimum station configuration was derived (Attachment XI.4). Since the requirement for a general long-range telephone service were provided to the program, the resulting station configuration is suitable for the growing needs of Alaska. This configuration served as the basis for the station finally proposed for the Indian Health Service.

XI.C. SIMPLICITY AND PERFORMANCE TEST OF THE STATION

--A low-cost (approximately $15,000) station, based on the optimum configuration was assembled from commercial components and demonstrated with Anik II in only two months.

In November 1973, Drs. Parker and Lusignan visited Alaska and met with representatives of the Indian Health Service, the Governor's Office, and RCA Alascom. The small stations were proposed and met with a mixed response. It was felt that if the prices were even near those predicted, the small stations would be the best choice for Alaska's rural communications. However, at that point, there was considerable skepticism of such a simple station actually working. The skepticism seemed well justified since the projected cost (approximately $15,000) was less than 1/20 of satellite stations familiar to most planners including RCA.

It was, therefore, recommended that a prototype station be demonstrated to confirm the simplicity and performance. Permission to use funds from this contract for such a demonstration was obtained in late December and a little over two months later, the station prototype was successfully demonstrated at Point Reyes, California with the Anik II satellite (Attachment XI.5). Point Reyes is in a position of the satellite antenna beam that is comparable to that of Anchorage, Alaska.

The demonstrations were attended by both State and Federal officials as well as representatives from the communications industry.

XI.D. PROVISIONS FOR MORE GENERALIZED TELEPHONE SERVICE

--The basic Point Reyes station design was developed to ensure that it has the flexibility to be expanded to meet general telephone communications needs and to be modified to use future satellites at minimum cost.

In our opinion, the station demonstrated at Point Reyes is the simplest and least expensive way to meet the Indian Health Service needs. However, to meet the more general needs of communications in Alaska's remote villages provision should be made to include within the station at some time a more generalized telephone service.

A set of specifications has been prepared (Attachment XI.6) that could serve as the basis for a competitive procurement of equipment. The equipment satisfies the basic health service needs. However, it also includes the ability to add receive only capability to serve radio distribution needs, and to add a general telephone service.

The simplest technique for adding phone service would be to provide service through a manual switchboard located in Anchorage. This technique is described in Attachment XI.7. The more sophisticated technique would be to add an automated system based on the Improved Mobile Telephone Service (IMTS) used for direct dial automobile phones. The IMTS equipment built by Motorola has been analyzed to ensure compatibility between it and the proposed satellite ground stations. The basic station options and the range of service configurations allowed by these options are described in Attachment XI.8.

Whether the simpler phone system or the more expensive automated system is adopted is a matter of ongoing discussions involving RCA and the State of Alaska. However, the cost of making the basic system compatible with either addition is very small.

XI.E. COMPATIBILITY WITH OTHER SATELLITE OPTIONS AND COSTS OF MODIFICATIONS

Adding the flexibility for a phone system based on the Anik satellite or the future RCA satellite is very easy to do. However, as pointed out by Howard Hupe of HEW's Office of Telecommunications Policy, the future options for Alaska mav include a wider range of satellite options (Attachment XI.9).

The basic station is compatible with any of the future satellites using the same 4-6 GHz frequencies. However, there are components that would have to be replaced with a change in operating frequencies, either 2.5 GHz or 12-14 GHz.

The antenna as presently specified, has an easily replaceable feed and can be pointed manually to different satellite locations. The reflector is suitable for 2.5 GHz and 4-6 GHz as presently specified and at a modest cost increase can have high efficiency at 12-14 GHz. Thus, for an antenna, the feed would have to be replaced to work with a satellite frequency change but the rest of the antenna, and the costs of its installation would not be wasted.

Most of the station cost is in the channelizing equipment. This equipment is largely unaffected by the satellite operating frequencies. A tighter specification would be needed for the reference frequency source to work with a 12-14 GHz satellite, and the final stages of the transmit and receive channels would be modified to provide the 2.5 GHz or 12-14 GHz frequencies. These are minor modifications to the existing designs.

The two major items that would have to be replaced with a satellite frequency change are the preamplifier and the power amplifier, both of which are optimized for a finite frequency range.

Thus, if the frequency were changed, items totaling about $6,500 would be taken from the stations: (preamplifier $1,200, antenna feed $800, power amplifier $4,500). Since these items are standard production items *in the normal microwave communications bands, they would have some* recovery value.

The cost of replacement items would be dependent on the characteristics of the new satellite. It could be as low as $5,900 (preamplifier $600, antenna feed $800, power amplifier $2,000, channel modification $2,500).

The station is already designed to minimize the cost of modification. The estimated installed cost is around $20,000. For addition of a general telephone capability and change to another satellite using the 4-6 GHz frequencies, none of that investment is made obsolete. A change to such a satellite seems the more likely future course.

If a future satellite is used having 2.5 GHz or 12-14 GHz for voice communications, less than one-third of the original investment would be replaced. In the meantime the station would have been supplying badly needed services for at least three years.

XI.F. ASSESSMENT OF THE PRESENT PLANS OF RCA ALASCOM

It appears that the present plans of RCA Alascom do not show promise of satisfying the Indian Health Service needs at a reasonable cost.

The best approach for the Indian Health Service to meet its needs would, of course, be to contract with an Alaskan common carrier for the services. RCA Alascom is the appropriate carrier in Alaska and Stanford has kept them informed at every stage of our work.

Before the optimum station configuration was identified, RCA had satellite stations planned in only a few of Alaska's larger cities, and along the oil pipeline route. The least costly stations cost well over $200,000.

Subsequent to the Point Reyes demonstration, Stanford was asked by Governor Egan's office to participate in a review of RCA's plans for Alaska. While RCA did make new proposals for Alaska, the proposals fell far short of what Alaska really needs. A series of subsequent proposals have been made moving closer to the small efficient stations. The latest proposal includes 10 ft. stations and RCA has asked for bids from equipment manufacturers. A copy of the request for quotations has been reviewed (see Attachment XI.10).

The analysis concludes that the Indian Health Service will not receive the low-cost communications it requires from the proposed RCA system. As specified, the ground stations will be two to three times as expensive as the optimum system. The Indian Health Service one way or another, will have to pay for the needless extra cost. For most of the Indian Health Service needs, conversation through the satellite will require two satellite hops incurring response delays of 1.2 seconds. This delay is very disturbing to normal conversations and would probably be very bothersome to medical consultation.

The RCA proposal may be turned down by the FCC because (1) it does not meet the FCC requirement for protection of adjacent satellites, and (2) it does not adequately protect the village from a dangerous level of microwave radiation. Both of these problems can be avoided by proper system design, and the cost of future Indian Health Service services and telephone services can be reduced by proper satellite design.

XI.G. CONCLUSIONS

It is our conclusion that, if the Indian Health Service wants its communications needs satisfied, it will have to take action to satisfy them itself rather than relying on the current plans of the Alaskan common carrier. The system described in Attachment XI.6 is sufficiently flexible to allow other State and Federal needs to be satisfied; and thus, there is an opportunity for the Indian Health Service to share the cost of the stations with other State and Federal agencies. It is also sufficiently flexible to allow the addition of a commercial telephone if an Alaskan common carrier is eventually interested.

CHAPTER XII

RECOMMENDATIONS FOR ACTION AND FUTURE RESEARCH

The findings of the evaluation research suggest the following recommendations for action:

XII.A. COMMUNICATION SERVICES

Reliable two-way voice communication should be provided between all communities with paramedical personnel in "Village Alaska" and the physician consultants. The communication system should have the following capabilities:

XII.A.1. 24-hour availability of a circuit for medical emergencies. (References: Medical emergencies, Attachment VI.1 and Ch. VI.A.3)

XII.A.2. Party line conference call capability to enable all parties to listen to medical exchanges for learning purposes and to permit interactive teaching and group discussions. (References: Health aides' opinions, Ch. VII.C; medical education evaluation, Ch. IX; community participation, Ch. II.A.2 and X.B)

XIII.A.3. Two-way simultaneous duplex circuits for private consultations (i.e. the equivalent of regular dial telephone service). (References: Health aides' opinions, Ch. VI.B.2)

XII.A.4. Location of the transceiver in a place chosen by the community to which the health aide has easy access. The site should permit private consultations between the health aide and doctor without being overheard by others in the local community, but should have facilities to allow patient presence and examination during the consultation. Space should also be available for small group interaction (e.g. for health education). The new Village Clinic Plan should be considered for these purposes. (References: Aides' access to radio, Ch. V.E and X.A; effect of listening to doctor on patient, Ch. X.C. and Hudson, 1972; health aides' opinions, Ch. VI.B.2)

XII.A.5. The remote sites should have speaker-phone capability so that groups can listen to and participate in exchanges. (References: Group involvement and mental health/sanitation problems, Ch. III.D; education, Ch. III.D, Ch. VII, and Ch. IX; family-hospital-patient contact, Ch. X.A)

XII.B. LEARNING THROUGH TELECOMMUNICATION

The health aides' learning from listening to the doctor call was analyzed in Chapter VII. The main finding of that chapter is that while a certain amount of learning is suggested by the data, learning occurs during a period of a few months, and after it, the improvement is quite marginal. (Reference: Learning, Ch. VII.C) Virginia Hunn Fowkes in Chapter IX of this report shows similarity in the improvement of learning scores for nurses receiving their instruction through this satellite radio system compared with peers receiving the same material in traditional classrooms at Bellevue Hospital in Washington. Similar findings were obtained using the radio of the Royal Flying Doctors for exchanges with "isolated" students in Australia. (Thomas, 1937) General research on learning and specific data about the use of interactive radio for teaching suggest that the possibilities for learning provided by the system are not fully exploited. One reason for this may be the prescriptive mode used by the doctors at the hospital (probably due to time considerations or other reasons). The research data do not indicate what specific actions should be taken; the following are examples of possibilities to explore:

XII.B.1. An experimental evaluation could be designed to assess the effects of a more analytical approach to the consultation, complementing the prescriptive advice of the doctor with teaching about exploration of symptoms, pathology, alternative hypotheses for diagnosis and strategies of therapy involved. (References: Expressed learning interest, Ch. VI.B.2 and VII.C; aide management plan, Ch. VI.A.4) This formative evaluation could test for changes in the ability of the aides to handle cases on their own, their increase in medical knowledge, and their management plan accuracy. The effect of short training periods for the consultant doctors in these teaching techniques could also be examined. An analysis of the more common diagnoses requiring radio consultation and their severity could determine priorities for teaching emphasis. (References: Most common diagnosis and severity, Ch. VI.A.4; also Ch. III) Coordination with the section of the ANMC responsible for the training of the health aides would be important.

XII.B.2. Another technique to increase learning would be to do a more complete follow-up to check for the effects of the therapies. (References: Number of consults per case, Ch. VI.B.2) The data show that the majority of the cases have only one consultation. The assumption is that the patient is doing well if he does not show up again. However, a more intensive follow-up of the results of the non-trivial therapies could be important to assess the efficacy of a treatment. Results of a treatment are important not only to the particular patient but also to other similar cases. (Reference: Aides' opinions on learning, Ch. VI.B.2. and VII.C) Doctors should encourage aides to follow up on specific cases and report on them.

XII.B.3. Another technique to explore is the analysis of the process of diagnosis and the management plan proposed by the health aide. The doctors should try to spot the weaknesses and offer remedial explanations.

XII.B.4. Printed material to help the verbal communication: it is considered important to provide charts of the human body and pictures or photographs of the different pathological signs to which both doctor and aides can refer in their exchanges. (References: Supportive printed material, Ch. IX; general literature about radio education, McAnany, 1973) The results of this innovation can be measured both in terms of predicted outcomes and in channel time use.

XII.C. COMMUNITY PARTICIPATION

The AANHS should consult with the Native Health Boards to determine how the communication system could be used to increase the involvement of communities in the analysis and solution of their health problems (including environmental and mental health). Possible areas for exploration are:

XII.C.1. Presentation of regularly scheduled interactive programs on topics of concern to the health boards or suggested by community leaders, health aides, etc.

XII.C.2. Encouragement of participation of village leaders and elders in discussions.

XII.C.3. Presentation of material on health professions and training programs available to people from remote communities which could enable them to perform more of the health care functions for their own people.

XII.C.4. Encouragement of health aides to train others in the community.

XII.C.5. Allocation of regular periods for exchange of messages between hospitalized patients and their families in the villages. (Reference: Importance of communication between hospitalized patients and family at village, Ch. X.A)

XII.D. MENTAL HEALTH

This study provides evidence that the doctor call can contribute to delivery of health care for physical problems. However, mental health is now a major problem in Alaska (e.g., see Chapter III).

Telecommunication alone will not change the socio-cultural environment in which the increase in mental health problems has developed. However, although only the consequences rather than the causes can be addressed, communication may be a useful tool in coping with mental health problems.

In consultation with the Native Health Boards, the following approaches could be tried and evaluated by the users and the Native Health Boards:

XII.D.1. Telediscussion and counseling on specific individual or family problems: Private consultations should be possible between community residents and trained psychiatric personnel and social workers. One approach would be an adaptation of the "crisis line" by providing a toll-free number which could be reached from any community. Peer counseling within the community and by toll-free telephone should also be explored.

XII.D.2. General programs on community mental health: A series of radio programs on recognized mental health problems could be organized to involve specialists, health aides, community leaders, and villagers in interaction over the radio.

XII.D.3. Non-medical communication: Access to interactive communication channels for a variety of uses (personal, educational, general information, entertainment) can have a positive effect on the psychological well- being of people in remote communities. Ways should be explored to maximize the opportunity for exchanges among the villages of cultural productions (e.g. radio programs, teleconferences, etc.) using the available communication networks.

The potential effect of the availability of television on mental health needs further study in remote Alaska communities. The availability of cable TV or mini-transmitters in some communities may permit such study.

XII.E. DOCTOR-TO-DOCTOR CONSULTATION

With reference to the communication system between remote doctors and their specialist colleagues at major medical centers, the data gathered support the following recommendations for action:

XII.E.1. Reliable two-way voice communication directly to a medical center for consultation should be provided to remote doctors. (Reference: Ch. VIII)

The Communication system should have the following capabilities:

XII.E.1.a. Regular consultation exchange once every two to three days. (References: Number of consultations exchanged, Ch. VIII.C.1; urgency of cases, Ch. VIII.C.2.b)

XII.E.1.b. Alarm button for emergencies, operative 24 hours. (Reference: Urgency of the cases, Ch. VIII.C.2.b)

XII.E.2. Additional communication capabilities (especially one-way video from the village to the hospital) can be of value in a significant number of cases. Systems should be explored that offer that capability as a special feature, to be used only when required (most of the consultations--about 80 percent--would not require more than two-way voice exchange). (Reference: Need for additional communication capabilities, Ch. VIII.C.5.d) Careful cost-benefit analysis should be done of this feature, because of the high costs involved.

XII.E.3. The lower value assigned to the radioconsultation by the remote doctor suggests the need for additional consideration. One possible reason for that difference could be that the consultations, instead of being considered as indicators of the physician's ability to deal with some cases at a higher level of sophistication, are considered as an indication of lack of mastery on a particular problem. (Reference: Difference in the perspective between remote doctor and consultant about the value of the consultation, Ch. VIII.C.5.e)

XII.F. RECOMMENDATIONS FOR FUTURE RESEARCH

The complexity and importance of this system both for Alaska and for other rural areas demand further research. Some of the areas to be developed have already been described, for instance, modes of radio interaction and their effects on the health aide learning and the outcome of the patient.

It would also be important to do trend analyses in the future when data about a long enough period of operation are available. Trend analysis could be especially useful in exploring changes over time in the health aide behavior as well as in the characteristics of the content of the exchanges; e.g., severity of the cases consulted, time elapsed, rate of confirmation of the aide management plan, etc. The analysis should also investigate the effect of the background of the health aide and process characteristics that can have positive effects on the health care. Trend analysis of hospitalization rates over a longer period of time can cast new light on some general and specific effects of improved telecommunication.

XII.G. NATIVE CONTROL IN DECISION-MAKING

Increased participation and control over decision-making should be given to the Natives, both to increase the accuracy in the definition of problems and solutions, and to increase their control over their own affairs.

XII.H. CONSIDERATIONS FOR PLANNING AN EXPANDED TWO-WAY COMMUNICATION SYSTEM

This study can provide valuable information for planning an expanded biomedical communication system. Several decisions are implied, including the following:

XII.H.1. Should the service include only the villages that had no telephone service or include as well those villages with current telephone access to the hospital? Given the interactive possibilities of the multi-node network, and the possible monopolization of the village line at certain hours by the health aide, we conclude that the villages having telephone service should also be included in the biomedical radio system with additional radio circuits for that purpose.

XII.H.2. Should the system include only predominantly native villages or also predominantly white villages? Given the jurisdictional responsibility of the AANHS, it might seem reasonable to include only those the villages that are considered "Native" by PHS definition. However, administrative constraints notwithstanding, we feel that this system should be integrated with a telecommunication system for all Alaska, providing this kind of service to any village without easy access to the hospital or doctor.

XII.H.3. Considering that the total amount of consultation for an expanded service will cover several hours per day, how many and which hours of the day are reasonable for health aide-doctor exchanges? As both the health aides and the doctors have other responsibilities besides radio consultations, we suggest that a simple survey be made among those in each service unit to determine the most convenient hours of the day for the radio call. (Reference: Inconvenience of certain hours for doctor call, Hudson, 1973)

XII.H.4. Should the present prescriptive mode of the exchanges be changed into a more "learning oriented" interaction, and how much more time would that new mode require? There was no attempt in this research to obtain evidence about the effects of these alternative modes. The eventual implementation of "learning oriented" interaction should be attempted on a formative basis. In other words, the different approaches should be tried to determine their effectiveness and to reorient the practice on the basis of that continuous learning. Perhaps the doctors and health aides themselves can suggest new techniques to be tried.

XII.H.5. Besides these considerations, planning of an expanded system for Bush Alaska communities requires other information which this study can provide, such as:

--Number of minutes of exchange per capita per year.

--Seasonal variations in the time required for biomedical exchange.

--Weekend vs. weekday variations in the time for exchanges.

--Number of villages per PHS unit, with certain levels of population and public services (electricity), type of population, and communication facilities.

--Inter-village variation and correlation with population size of the village.

This information is valuable for estimating requirements for various configurations of an expanded system. For example, let us assume the following data and try a very simple example of the planning calculation:

--9.345 minutes of exchange per capita per year (Ch. V)

--maximum length of doctor call: 90 minutes

--daily doctor call, including weekends

--all 167 native villages with population from 25-1,000

--present PHS boundaries

--more explanatory mode of interaction (assuming an allocation of 30 percent more time for this)

--no seasonal variation, no weekend variation

Using the native population in villages within each PHS unit, we have done the calculations to estimate the number of groups necessary to cover the seven units of the AANHS under these assumptions. They are:

Service Unit	Population	Average Consultation Time Per Capita + 30%
Anchorage	5,673 persons	x (9.345 x 1.30) = 68,918 minutes per year
Barrow	415	5,041
Bethel	9,322	113,248
Kanakanak	2,980	36,202
Kotzebue	5,444	66,136
Mt. Edgecumbe	4,849	58,908
[illegible]anana	3,173	38,547

365 sessions of 90 minutes each would take 32,859 minutes per year. Therefore, to provide doctor calls not to exceed 90 minutes, the following breakdown of villages into doctor-call groups would be required:

Anchorage: two groups of villages (i.e., 68,918/32,850 = 2.09)

Barrow: one group

Bethel: three groups

Kanakanak: one group

Kotzebue: two groups

Mt. Edgecumbe: two groups

Tanana: one group

Total: 12 groups

Planners can use this approach and the data in this evaluation to make estimates under different sets of assumptions. For example, if an hour and a half for the average daily exchange is considered too long, or if other assumptions are changed, new results can be calculated from the data. Similar calculations could be done if the doctor-to-doctor consultation were to be expanded to serve other remote communities. These calculations have been done not to achieve a definitive result, but to familiarize the reader with a simple method of calculation which he can use to make estimates using different assumptions.

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ATTACHMENTS

Attachments to Chapter II

II.1 Telephone in the Villages by Public Health Service Unit and Population Type

II.2 Television in the Villages by Public Health Service Unit and Population Type

Attachment II.1

TELEPHONE IN THE VILLAGES (April 1974)

(Communities with 25-1,000 population)

PHS Unit and Predominant Population Type	With Commercial Telephone	Without Telephone	Total
Anchorage			
Native	13	24	37
Non-native	35	7	42
Barrow			
Native	3	1	4
Non-native	1	1	2
Bethel			
Native	20	28	48
Non-native	-	1	1
Kanakanak			
Native	11	19	30
Non-native	-	2	2
Kotzebue			
Native	15	13	28
Non-native	2	1	3
Mt. Edgecumbe			
Native	10	-	10
Non-native	32	8	40
Tanana			
Native	6	17	23
Non-native	8	5	13
Total Native	78	102	180
Total Non-native	78	25	103
TOTAL	156	127	283

Attachment II.2

TELEVISION IN THE VILLAGES (April 1974)

(Communities with 25-1,000 population)

PHS Unit and Predominant Population Type	No Television Reception	Direct TV (from Anch., Fairbanks, or translator station)	TV with mailed tapes	Air Force Translator	Uncertain
Anchorage					
Native	33	3	3	-	-
Non-native	16	34	4	2	2
Barrow					
Native	2	-	1	-	-
Non-native	1	-	-	-	-
Bethel					
Native	42	1	-	1	-
Non-native	2	-	-	-	1
Kanakanak					
Native	22	1	-	6	-
Non-native	-	-	-	2	-
Kotzebue					
Native	31	-	1	-	-
Non-native	-	-	-	-	3
Mt. Edgecumbe					
Native	10	-	-	-	-
Non-native	18	13	9	-	-
Tanana					
Native	19	2	1	1	1
Non-native	3	13	-	-	4
Total Native	159	7	6	8	1
Total Non-native	40	60	13	4	10
TOTAL	199	67	19	12	11

Attachments to Chapter III

III.1 Comparison of Vital and Health Statistics of Alaska Natives with U. S. (all races) (1950-1972)

III.2 Alaska Native Health Service--Ten leading notifiable diseases (1972-1971)

III.3 Alaska Native Health Service--Ten leading causes of hospitalization (1972-1966)

III.4 Hospitalization rate for Native Alaskans compared with the U. S. Population

COMPARISON OF VITAL AND HEALTH STATISTICS OF ALASKA NATIVES WITH UNITED STATES (ALL RACES)

VITAL/HEALTH STATISTIC	YEAR	ALASKA NATIVE	U.S. (ALL RACES)	RATIO (NATIVE/U.S.)
Crude Death Rate (deaths per 1000 population)	1950	16.8	9.5	1.8
	1960	9.4	9.5	1.0
	1970	7.4	9.4	0.8
Infant Mortality Rate (deaths per 1000 live births)	1950	94.0	29.2	3.2
	1960	74.8	26.0	2.9
	1970	28.5	19.8	1.4
Tuberculosis Death Rate (deaths per 100,000 pop.)	1950	652.9	22.5	29.0
	1960	25.5	6.1	4.2
	1972	0.0	2.2*	0.0
Tuberculosis Incidence Rate (cases per 100,000 pop.)	1952	1854.3	70.5	47.1
	1960	436.6	39.4	11.1
	1972	149.2	17.0*	8.8
Birth Rate (births per 1000 population)	1950	40.5	24.1	1.7
	1960	47.8	23.7	2.0
	1971	32.4	18.2*	1.8
Life Expectancy (years)	1959-61	60.4	69.7	0.9

* 1971

SOURCE: Office of Systems Development, Alaska Native Health Service
State of Alaska, Section of Tuberculosis Control and Chest Diseases

Office of
Systems Development

Attachment III.2

February 9, 1973

ALASKA NATIVE HEALTH SERVICE
TEN LEADING NOTIFIABLE DISEASES
(RANKED IN ORDER OF INCIDENCE)
1972 - 1971

Disease	Cases				Percent Change
	1972		1971		
	Number	Rank	Number	Rank	'72/'71
Total Reported Notifiable Diseases	20,630 1/	-	13,909	-	48.3
Total Ten Leading Notifiable Diseases	19,474	-	13,241	-	-
Upper Respiratory Infect., C/Cold	7600	1	3672 2/	2	107.0
Acute Otitis Media	4297	2	4195	1	2.4
Strep Throat	2156	3	1686	3	27.9
Gonococcal Infections	1378	4	1288	4	7.0
Gastroenteritis, Diarrhea	1335	5	380	8	251.3
Impetigo	907	6	532	7	70.5
Influenza	900	7	597	6	50.8
Pneumonia (excl. NB)	655	8	727	5	-9.9
Chickenpox	127	9	115	10	10.4
Bacillary Dysentery	119	10	49	15	142.9

1/ Increase partially due to a change in disease coding.
2/ Does not include "common cold" diagnosis.

SOURCE: Office of Systems Development, Alaska Native Health Service
Community Health and Epidemiology Branch, Alaska Native Health Service
IHS Inpatient/Outpatient Reporting System

Office of
Systems Development

Attachment III.9

February 9, 1973

TEN LEADING CAUSES OF HOSPITALIZATION REQUIRING THE ADMISSION OF ALASKA NATIVES TO HEALTH SERVICE HOSPITALS
FY 1972 - FY 1966

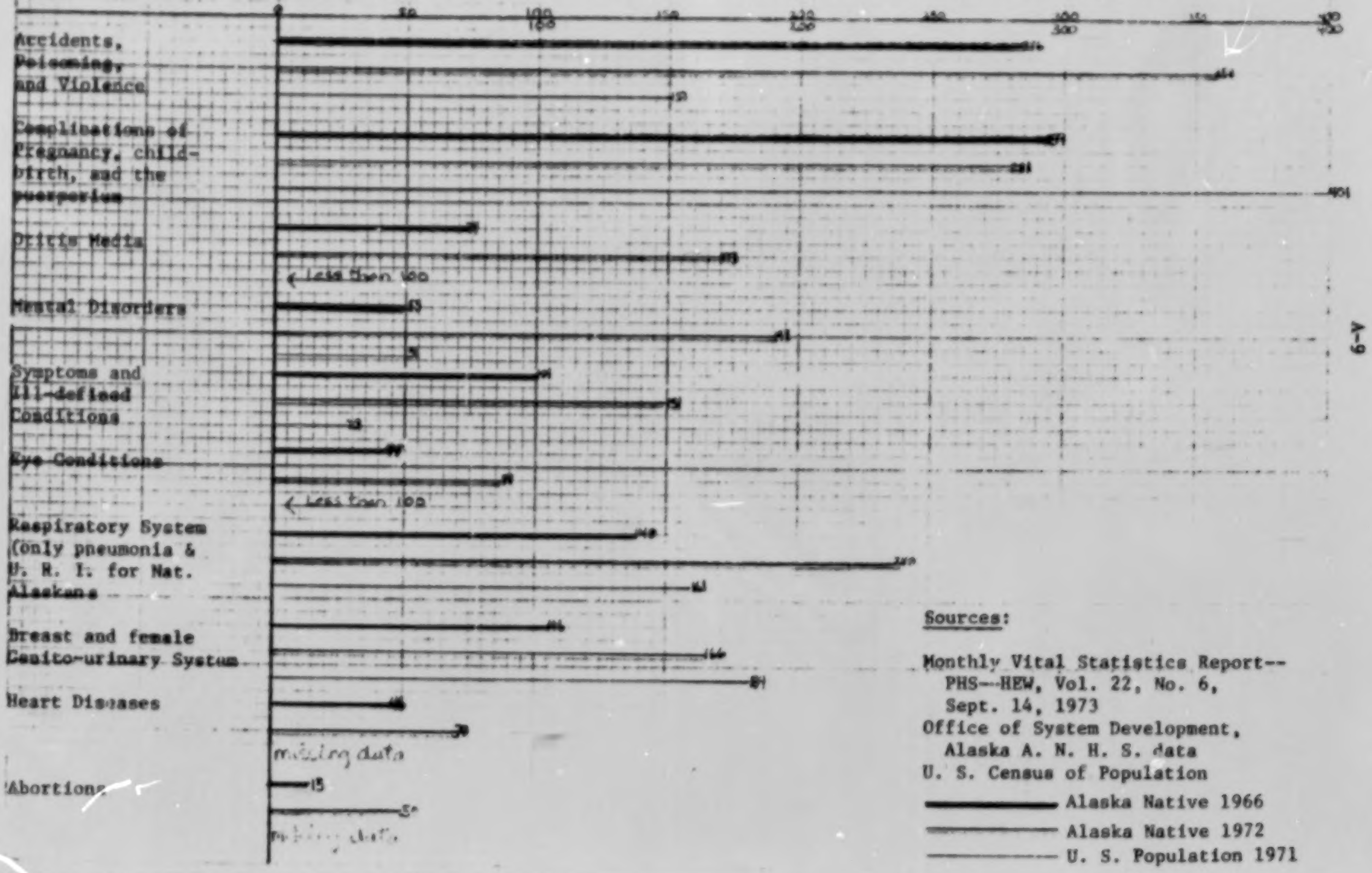
Rank	Cause of Hospitalization	Admissions		Percent Change
		FY 1972	FY 1966	'72/'66
	Total Admissions - All Diagnosis	11,199	10,068	11.2
	Total Admissions - Ten Leading Causes	6409	4621	-
1	Accidents	1420	1061	33.8
2	Delivery	1067	1188	-10.2
3	Otitis Media	863	303	184.8
4	Psychotic, Psychoneurotic & Personality Disorders	663	200	231.5
5	Symptoms, Senility & Ill-Defined Conditions	565	333	69.7
6	Diseases of the Eye	473	212	123.1
7	Pneumonia	459	817	-43.8
8	Diseases of the Breast and Female Genital Organs	346	266	30.1
9	Diseases of the Heart	287	168	70.8
10	Abortion	266	73	264.4

SOURCE: Office of Systems Development, Alaska Native Health Service

Attachment III,4

HOSPITALIZATION RATE FOR NATIVE ALASKANS COMPARED WITH THE U. S. POPULATION

For Native Alaska: Number of Admissions to H. S. Hospital and Contract Hospital 1972; per 10,000 population
For U. S. Population: Number of discharges to Short Stay Hospital 1971; per 10,000 population



Sources:

Monthly Vital Statistics Report--
PHS--HEW, Vol. 22, No. 6,
Sept. 14, 1973
Office of System Development,
Alaska A. N. H. S. data
U. S. Census of Population

Attachment to Chapter IV

IV.1 List of villages where satellite radio ground stations were installed as a result of the ATS-1 Biomedical Communication project.

Attachment IV.1

List of villages where satellite radio ground stations were installed as a result of the ATS-1 Biomedical Communication Project

	Installed in:
Allakaket	August 1971
Anaktuvuk Pass	August 1971
Anchorage	August 1971
Arctic Village	August 1971
Barrow	August 1971
Beaver	April 1973
Bethel	August 1971
Circle	April 1973
Chalkyitsik	August 1971
Emmonak*	August 1971
Fairbanks	August 1971
Fort Yukon	August 1971
Galena	August 1973
Homer*	August 1971
Hooper Bay*	August 1971
Hughes	April 1973
Huslia	August 1971
Juneau	August 1971
Kaktovik*	August 1971
Kanakanak*	August 1971
Kodiak	August 1971
Kotzebue	August 1971
Koyukuk	April 1973
Nome	August 1971
Nulato	August 1971
Ruby	August 1971
St. Paul	August 1971
Sand Point*	August 1971
Stevens Village	August 1971
Tanana	August 1971
Venetie	August 1971

* Dismantled in 1972

Attachment to Chapter V

V.1 Facsimile of radiolog kept daily at the Minitrack Station--University of Alaska, College.

V.2 Aide-to-doctor contacts via ATS-1, 1973.

DATE: 30 NOV 73	ON: 0501 OFF: 0700			ON: OFF:			ON: 2000 OFF: 2100			ON: 2130 OFF: 2330 DR BRITTON			S.I. = 24 FRIDAY		
STATIONS	Participation *	Signal	Program Content	Participation *	Signal	Program Content	Participation *	Signal	Program Content	1st Transmission to Tanana	Signal	No. Patients Treated	Time Used For Treatment	No. Other Medical Matters	Total Elapsed Time
Allakaket			NURSES' SEMINAR						LIBRARY	2137	5x5	1	2	1	2
Anaktuvuk Pass										2139	5x5	1	2	0	2
Arctic Village										2210	5x5	2	7	1	8
Beaver							A	5x5		2141	4x5	1	2	0	2
Chalkyitsik										2143	5x5	1	3	0	3
Eagle										2146	5x5	1	3	1	5
Fort Yukon										2151	5x5	0		3	8
Hughes										2227	5x5	1	4	0	4
Huslia										2220	5x5	1	5	3	7
Koyukuk										2233	5x5	0		2	3
Nulato										2232	5x5	0		2	1
Ruby							A	5x5		2236	5x5	0		2	2
Stevens Village										2238	5x5	1	3	0	3
Venetie							A	5x5		2242	5x5	1	2	2	2
Galena										2202	5x5	3	8	0	8
Kotzebue	A	5/5													
Nome	A	5/5													
Barrow	A	4/4													
Tanana										2137	5x5				65
Saint Paul										2130	5x5			8	17
Anchorage										2130	5x5			8	17
College	A						A								
Juneau	A	5/5					A	5x5							

NOTES: 0504z Nome reports remote unit has problems (electricians working in area where unit is) / Barrow reports a lot of interference (battery going down, 60 H hum on xmit signal)

2238 RUBY SUB-AIED AID ADVISED THAT IF SHE DOESN'T HAVE TRAFFIC THIS WEEKEND SHE WILL NOT BE AT RADIO.

2300 NULATO (PAULINE) APOLOGIZED FOR NOT ANSWERING ON WEEKENDS WHEN SHE DOESN'T HAVE TRAFFIC BUT EXPLAINED THAT IT'S A LONG WALK (OVER ½ MI EACH WAY) TO CLINIC.

* A = Active Participation
L = Just Listening

Attachment V.3

Aide-to-Doctor Contacts via ATS-1

(1973, for 13 villages*)

	Numbers	% of total possible contacts	% of completed contacts
Possible contacts**	4,257	100	---
Contacts completed***	3,676	86.4	100
Contacts completed with biomedical content****	2,871	67.4	78.1
Contacts completed with biomedical content including patient consultations*****	1,836	43.1	49.9
Contacts not completed	581	13.6	15.8

* 4 villages entered the system in April 1973.

** Possible contacts: number of villages x number of days they have been operating within the radio satellite system.

*** Contacts completed: Doctor calls answered by the health aide.

****Contacts completed with biomedical content: Cases in which the health aide and the doctor had at least one patient consultation or one administrative matter to exchange.

*****Contacts completed with biomedical content including patient consultations: Cases in which the health aide and the doctor had at least one patient consultation.

Attachments to Chapter VI

VI.1 List of examples of emergency cases where communication was an important factor.

VI.2 Example of log of medical radioconsultation kept by the doctors at Tanana Hospital.

VI.3 Codes for the description of the consultation in terms of:

--type of visit ("visit")

--need for travel ("travel")

--severity of the case ("severity")

--confirmation of the health aide management plan ("management")

--predicted effect of the consultation on the outcome ("outcome")

VI.4 Demographic data of the villages considered

VI.5 Hospitalization rates: for ANMC

VI.6 Hospitalization rates: for Tanana Hospital

VI.7 Hospitalization rates: for both PHS hospitals

VI.8 Codes of Diseases

VI.9 Sample "Doctor Call" Transcript

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Attachment VI.1

Examples of Emergency evacuation over the past two years where communication was an important factor. From Dr. Brian Beattie's notes taken during interviews with health aides (1972).

Danny: about Christmas, 1969 -- burned at 11p.m. in evening. No way to talk to physicians...Went in on plane at dawn. Sent to Anchorage. Communication would have helped reassure people they were doing the right thing.

Todd: April, 1970, 5 months old. Rectal temp 105, P=85, R=99. Sponged to 103.8, congested chest, shallow breathing, slight cold for 2 weeks, whimpered, not active.
Got hold of physician in Tanana ahead of time via Galena and got plane going through Ruby.
Had meningitis.
Better communication might have helped with increased penicillin and oral ampicillin (no I.M. ampicillin in village anyway) and might have helped patient get in sooner.

Ricky: about 20, January, 1971. Shot off part of thumb.
Called Tanana on radio and patient went to Fairbanks next day, charter or mail plane.

Sarah: about 24, November, 1971. 7 months pregnant, half day bleeding. got sick in evening. Satellite radio was used to evacuate patient next morning and charter to Fort Yukon and on directly to Fairbanks. Patient had lost close to half blood volume.
Communication helped a great deal.

Marie: November, 1971, 2 months pregnant. Attempted to contact Ft. Yukon or Tanana for 2 days by radio without success.
Blood pressure dropped to 90 systolic. Finally stopped bleeding. Patient recovered.

Christian: Autumn, 1971. Caught finger in generator in afternoon. Open

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fracture of one finger, closed of 2 others. Used school radio to call Tanana. Charter to Fairbanks.
Bad enough to require charter. Communication may have prevented infection.

Joel: 13, October, 1972. Stabbed with small knife in back lateral. Late at night. Called Tanana on satellite radio next day and told to send to Fort Yukon. Communication facilitated transportation. Not a serious wound.

George: 14, January, 1972. Broke ankle in sno-go accident. Belt broke. Ankle swollen and black and blue.
Radio didn't work. Teacher from Galena came with plane by chance. The plane went up and radioed Galena. The nurse from Galena came down the same day with a charter pilot and the patient was taken to Tanana. They would have had to keep calling or wait for a plane if one had not come.

Patricia: 22, April, 1972. Sick to stomach in a.m. Temp. to 103.
Pain in right side.
Tried to get Tanana 8-8:30p.m. Got Fairbanks next morning.
Got worse at night.
Ft. Yukon chartered her to Fairbanks in a.m. Appendix not ruptured.
Radio would have made some difference in getting a plane sooner and consulting with the doctor.

Bill: about 30, September, 1972. 3a.m. Broke leg walking down steps. Obviously broken.
Tried to call Tanana 6a.m. and 7a.m. Teacher called Tanana on his plane radio and got a charter plane to take patient to Tanana.

Alvin: January, 1972. About 9p.m. Threw water on jet fuel fire (Jet fuel pulled out of river and used by mistake instead of coal oil).
Severe third degree burns of entire trunk.
Got Dr. Brown in Tanana on [HF] radio that night and advice given.
Chartered out at noon next day to Galena and to Anchorage by Air Force plane.
Radio worked and helped.

Kenneth: 11, February, 1971. About 11p.m. Chest burns from Blazo (thought it was kerosene; Blazo like gas)
No luck with school radio. Father went to Galena, took 1 and 1/2 hours by Sno-go.
Patient chartered out in a.m. by plane from Galena.
Radio would have helped. Would have saved somewhat long sno-go trip.

Four girls: May, 1972. Multiple #4 shot wounds, 11p.m.
Talked with charter pilot in Galena on school radio. Patients picked up 1/2 hour later and sent to Galena. Cared for by public health nurse in Galena. Wounds not serious.
Radio fortunately worked.

Examples of deaths which might have been prevented if the health aide had had reliable communication with the outside:

Baby: one month, January, 1971.
Slight cold the day before; baby died that night. Mother up most of night. Premature baby.
Breathing got worse and worse during night. Mother didn't come to health aide second time until baby dead.
Communication might have made a difference in whether or not mother came to health aide and in whether or not the baby could have been evacuated to Tanana. May have been a case of poor communication between mother and health aide.

William: 19 years old, December, 1970. Left on Sno-go for mountain, 20 miles away, to hunt, December 23. Poorly dressed and had no matches. Storm for 3 days. Found December 26.
Called Fort Yukon December 24, and Army helicopter found him. They could not search until the weather broke.
Communication might have helped if used first night.

Neil: about 45, January, 1969. Drinking heavily. Started to vomit coffee grounds during the night. Health aide obtained at 10a.m., and

she and teacher tried from 10a.m. to 9p.m. to get help on the state radio. Patient died at midnight.
Communication might have saved this patient.

Sam: about 70, January, 1970. Hong Kong flu going around, got pneumonia? Temp. 103-104. Fever 2 days. Was on pills. Felt OK during day, sick at night. Died 10-11a.m.
Health aide feels radio would have made a difference if patient had been reported right away.

Ben: 65-70, November, 1970. Chest pain one day, but nothing bad. Was checked and seemed OK.
In late evening chest pain came back, someone stayed overnight with him. Died during night. Health aide feels it was a heart attack. Tried all day to get Fort Yukon, Tanana, Fairbanks on school radio. No luck. Communication might have helped.

Pauline: about 70, December, 1969.
From record: "Daughter says she has been vomiting 'brown water' every evening for a week--not food. Attempted to contact doctor today. She is vomiting continuously--greenish now. Told to not take anything by mouth. Improved by evening. Attempted to give a phenobarb-belladonna tablet--vomited 1/2 hour later. Passed away at about 6:45a.m.."
Probably wouldn't have got her to Tanana even if good communication, but communication might have helped.

Examples of cases in which the availability of 24-hour emergency communication via satellite radio might have helped:

Male, 19: Fractured mandible (jaw). Patient evacuated by local teacher's plane approximately 4 hours after injury. Communication via HF radio attempted unsuccessfully. Satellite radio not on at this time of day. Reliable 24-hour communication might have prevented a plane trip in marginal weather.

Female, 27: Alcohol withdrawal or pneumonia. After some time, Tanana contacted by HF relay through Kotzebue. Satellite radio not on at this time of day. Patient taken out by charter and apparently did OK.

Female, 11: Abdominal pain. Satellite radio not on at this time of day. Taken to Tanana in local teacher's plane. Apparently did OK. Communications may have saved trip.

Male, 18: Ultraviolet burns of cornea (eye) from welding. Talked with physician on satellite radio and sent to Fort Yukon by regular plane next day (patient had recovered). Reliable 24-hour communication may have saved an unnecessary trip.

Female, 2: Ingested 2 Hydroclorothiazide tablets (diuretic) instead of Aspirin. As an airplane happened to be in the village, the health aide chartered to Tanana with the Mother. A consultation could have saved the trip.

Attachment VI.2

VILLAGE____________________ MONTH/YEAR__________ HEALTH AIDE____________________

Date N.C., Neg. Admin., Emerg.	PATIENT'S			Clinical Information; Impression/Diagnosis; Advice/Rx	Visit	Travel	Severity	Management	Outcome
	Name	Age	Sex						

Attachment VI.3

CODES

TYPE OF "VISIT"

1. Acute problem.
2. Acute followup.
3. Chronic management.

TRAVEL

1. Travel not considered.
2. Considered, but not authorized.
3. Authorized on routine basis.
4. Authorized urgent.

SEVERITY

1. Simple question by phone or in person about medication, reaction, or use of household remedy, etc.
2. Patient counseling about proper health habits, social or psychological problems.
3. Routine screening, history, and physical on an asymptomatic individual, e.g., school, athletic executive evaluations.
4. Follow-up of and resolving acute problem that has been under treatment.
5. Evaluation of new minor, but symptomatic problems related to a particular organ system, URI, urinary tract, etc. with little potential to become severe problem or chronic disease process with little potential for mortality.
6. Evaluation of new moderately severe problem with potential for deterioration to severe problem or to disability or chronic disease process with moderate potential for mortality.
7. Evaluation of acute problem producing severe symptoms or potential disability or a chronic process with high potential for mortality.

SEVERITY (Con't)

8. Evaluation of continuing severe problems of life threatening proportions requiring analysis of several diagnostic and therapeutic possibilities and frequent evaluation of course and therapy.

MANAGEMENT

1. Confirm health aide treatment.
2. Suggested treatment but aide could have managed.
3. Made minor treatment change.
4. Significant change or addition to management.

OUTCOME

1. No effect on eventual outcome.
2. Some effect probably only relative to symptoms, probably not influencing future disability.
3. Definite effect relating to future wellbeing or prevention of disability.
4. Marked effect possibly life saving or prevention of major disability.

Attachment VI.4

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DEMOGRAPHIC DATA ABOUT THE EXPERIMENTAL GROUP AND THE CONTROL GROUP OF VILLAGES

From the SPIRES file.

SATELLITE VILLAGES (experimental group)

COMMUNITY(S)	POP	NPOP	N%	A	PO	WT	T	RA	S	PS	PR	MA	LA LO
Allakaket	174	168	97	1	0	0	0	2	X	6	100	1	66x152
Anaktuvuk Pass	99	97	98	1	0	0	0	2	X	0	0	1	68x151
Arctic Village	85	82	97	1	0	0	0	2	X	0	0	1	68x145
Chalkytsik	130	123	95	1	0	0	0	2	X	0	0	1	66x143
Huslia	159	151	95	1	0	0	3	2	X	6	100	1	65x156
Nulato	308	298	97	1	0	0	3	2	X	6	100	1	64x158
Ruby	145	134	92	1	0	0	3	2	X	0	0	1	64x155
Stevens Village	74	72	97	1	0	0	4	1	X	0	0	1	66x149
Venetie	112	108	96	1	0	0	0	4	X	0	0	1	67x146
	1286	1233											

NON-SATELLITE VILLAGES(control group)

COMMUNITY(S)	POP	NPOP	N%	A	PO	WT	T	RA	S	PS	PR	MA	LA LO
Beaver	101	86	85	1	0	0	1	4	X	0	0	1	66x147
Cantwell	62	43	69	2	1	0	5	1		0	0		63x148
Circle	54	32	59	1	1	0	6	2		6		1	65x144
Hughes	85	73	86	1	0	0	3	2	X	1	100	1	66x154
Kaltag	206	193	94	1	0	0	5	2		6	100	1	64x158
Koyukuk	124	121	98	1	0	0	3	3	X	0	0	1	64x157
Minto	168	159	95	1	1	0	4	2		6	100	1	65x149
Nenana	362	142	39	2	1	0	5	0		6	100	1	64x149
Rampart	36	21	58	1	0	0	4	2		0	0	1	65x150
	1198	870											

reference code attached

Reference Code for

ALASKA COMMUNITIES FILE in SPIRES System

POPULATION
POP = TOTAL POPULATION FOR COMMUNITY
NPOP = NATIVE POPULATION FOR COMMUNITY
N% = NATIVE POPULATION/TOTAL POPULATION

TRANSPORTATION
A = AIRPORT
  0 = UNAVAILABLE
  1 = SCHEDULED SERVICE
  2 = UNSCHEDULED SERVICE
RO = ROADS
  0 = UNAVAILABLE
  1 = AVAILABLE
WT = WATER TRANSPORTATION
  0 = UNAVAILABLE
  1 = FERRY
  2 = RIVERBOAT

COMMUNICATION
T = TELEPHONE
  0 = UNPLANNED
  1 = EXISTING RCA BUSH TELEPHONE
  2 = RCA BUSH TELEPHONE PLANNED, PHASE ONE
  3 = RCA BUSH TELEPHONE PLANNED, PHASE TWO
  4 = RCA BUSH TELEPHONE PLANNED, PHASE THREE
  5 = COMMERCIAL TELEPHONE AVAILABLE
RA = HIGH FREQUENCY RADIO AVAILABLE
  0 = UNAVAILABLE
  1 = PRIVATE
  2 = STATE
  3 = PUBLIC HEALTH SERVICE
  4 = BUREAU OF INDIAN AFFAIRS
  5 = UNKNOWN OWNER
S = SATELLITE
  X = LINK AVAILABLE
  (BLANK = UNAVAILABLE)

POWER
PS = SOURCE
  0 = UNAVAILABLE
  1 = INDIVIDUAL GENERATOR
  2 = DIESEL GENERATOR
  3 = TIE LINE
  4 = SCHOOL GENERATOR
  5 = REA
  6 = POWER AVAILABLE, SOURCE UNKNOWN
PO = DISTRIBUTION
  (SHOWN AS: % OF RESIDENTS WITH POWER)

HEALTH AIDES
HA = NUMBER OF HEALTH AIDES ASSIGNED
  (BLANK = NONE)

Reference Code for ALASKA COMMUNITIES FILE in SPIRES System, Continued

COORDINATES
LA = LATITUDE
LO = LONGITUDE

NOTE: BLANKS are to be treated as an indication of MISSING DATA except as noted under SATELLITE and HEALTH AIDES.

Attachment VI.5

ANMC HOSPITAL

Hospitalization Rates Before and After Satellite Installation

	Satellite Villages			Non-Satellite Villages		
	Before	After		Before	After	
	FY 1970	FY 1972	FY 1973	FY 1970	FY 1972	FY 1973
Number of Patients						
--16 categories of medical diseases	32	32	50	50	28	24
--Pregnancy/delivery	1	2	7	2	2	1
--Sociobehavioral	8	4	7	10	11	9
--Supplemental	12	10	14	8	3	4
Total	53	48	78	70	44	38
Days of Stay						
--16 categories of medical diseases	997	630	878	1,461	599	545
--Pregnancy/delivery	11	8	53	27	36	3
--Sociobehavioral	121	96	189	478	178	228
--Supplemental	179	73	109	121	36	31
Total	1,308	807	1,229	2,087	849	807
Average Length of Stay						
--16 categories of medical diseases	26.9	19.7	17.6	29.2	21.4	22.7
--Pregnancy/delivery	11	4	7.6	13.5	18	3
--Sociobehavioral	15.1	24	27	47.8	16.2	25.4
--Supplemental	14.9	7.3	7.8	15.1	12	7.7
Average in all cases	22.5	16.8	15.7	29.8	19.3	21.2

Attachment VI.6

TANANA HOSPITAL

Hospitalization Rates Before and After Satellite Installation

	Satellite Villages			Non-Satellite Villages		
	Before	After		Before	After	
	FY 1970	FY 1972	FY 1973	FY 1970	FY 1972	FY 1973
Number of Patients						
--16 categories of medical diseases	94	109	84	66	66	35
--Pregnancy/delivery	20	19	16	8	12	0
--Sociobehavioral	49	40	48	25	31	28
--Supplemental	34	62	50	16	29	8
Total	197	230	198	115	138	71
Days of Stay						
--16 categories of medical diseases	773	914	987	453	698	475
--Pregnancy/delivery	282	354	304	146	225	0
--Sociobehavioral	375	400	395	248	197	336
--Supplemental	198	248	329	86	202	87
Total	1,628	1,916	2,015	933	1,322	898
Average Length of Stay						
--16 categories of medical diseases	3.3	8.3	11.7	6.9	10.6	13.6
--Pregnancy/delivery	14.1	18.6	19	18.2	18.7	0
--Sociobehavioral	7.6	10	8.2	9.9	6.3	12
--Supplemental	5.8	4	6.6	5.4	6.9	10.9
Average in all cases	8.3	8.3	10.1	8.1	9.6	12.6

Attachment VI.7

BOTH HOSPITALS

Hospitalization Rates Before and After Satellite Installation

	Satellite Villages			Non-Satellite Villages		
	Before	After		Before	After	
	FY 1970	FY 1972	FY 1973	FY 1970	FY 1972	FY 1973
Number of Patients						
--16 categories of medical diseases	131	141	134	116	94	59
--Pregnancy/delivery	21	21	23	10	14	1
--Sociobehavioral	57	44	55	35	42	37
--Supplemental	46	72	64	24	32	12
Total	255	278	276	185	182	109
Days of Stay						
--16 categories of medical diseases	1,770	1,542	2,226	1,870	1,323	934
--Pregnancy/delivery	293	362	357	173	261	3
--Sociobehavioral	496	496	584	726	375	564
--Supplemental	377	521	438	207	238	118
Total	2,936	2,921	3,605	2,976	2,197	1,619
Average Length of Stay						
--16 categories of medical diseases	13.5	10.9	16.6	16.2	14.1	15.8
--Pregnancy/delivery	13.9	17.2	15.5	17.3	18.6	3
--Sociobehavioral	8.7	11.2	6.8	20.7	8.9	15.2
--Supplemental	8.2	7.2	6.8	8.6	7.5	9.8
Average of all cases	11.1	11.6	13.1	16.1	12.07	14.9

Attachment VI.8

Categorizations of Diagnosis and Groups of Diagnosis in Four Major Categories (inpatient diagnoses)

FIRST CATEGORY: PROBLEMS WITH CLEAR PHYSIOLOGICAL ORIGIN AND MANIFESTATION

(16 Categories of Medical Diseases)

Tuberculosis
Venereal diseases, all forms
Infectious disease commonly arising in intestinal tract
Other bacterial diseases
Diseases attributable to viruses
Other infective and parasitic diseases
Malignant Neoplasms
  Buccal cavity and pharynx
  Digestive organs and peritoneum
  Respiratory system
  Breast and genitourinary organs
  Other and unspecified sites
  Lymphatic and hematopoietic tissue
Benign and unspecified neoplasms
Diseases of thyroid gland
Diabetus mellitus
Disease of other endocrine glands
Avitaminoses and other metabolic disease
Diseases of blood and blood-forming organs
Inflammatory diseases of central nervous system
Other diseases of central nervous system
Disease of nerves and peripheral ganglia
Other disease and conditions of eye
Otitis Media
Other diseases of ear and mastoid process
Vascular lesions affecting central nervous system
Rheumatic fever
Chronic rheumatic heart disease
Arteriosclerotic and degenerative heart disease
Other disease of heart
Hypertensive heart disease
Disease of arteries, veins and other diseases
Acute upper respiratory infections
Influenza
Pneumonia
Bronchitis
Other disease of repiratory system
Allergic disorders
Disease of buccal cavity and esophagus
Disease of stomach and duodenum
Appendicitis
Hernia of abdominal cavity
Other disease of intestines and peritoneum

5

Disease of liver, gallbladder, and pancreas
Nephritis and Nephrosis
Other diseases of Urinary System
Disease of Male Genital Organs
Diseases of Breast and Female Genital Organs
Infections of Skin and subcutaneous tissue
Other diseases of skin and subcutaneous tissue
Arthritis and rheumatism
Osteomyelitis and other diseases of bone and joint
Other diseases of musculoskeletal system
Congenital malformations
Certain diseases of early infancy

SECOND CATEGORY: "SOCIO-BEHAVIORAL" PROBLEMS

Mental Disorders
- Acute brain disorders
- Chronic brain disorders
- Psychotic, psychophysiologic, psychoneurotic, personality disorders and mental deficiency
- Alcoholism

Accidents
- Fractures
- Dislocations, sprains, and strains
- Head Injury (excluding skull fracture)
- Internal injuries of chest, abdomen and pelvis
- Lacerations and open wounds
- Superficial injuries, contusions
- Burn
- Adverse effects of chemical substances
- Other adverse effects

THIRD CATEGORY: PREGNANCY, DELIVERY, AND COMPLICATIONS

Complications of pregnancy
Abortion
Delivery
Complications of the puerperium

FOURTH CATEGORY: (RESIDUAL)

Symptoms, Senility, and Ill-defined conditions
Supplemental treatment
Special conditions and examination without sickness

ATTACHMENT VI.9

The following sample transcripts have been excerpted from several different days of "Doctor Call." They are included here to give a general impression of how audio teleconsultations sound. These excerpts are taken from tapes of the interactions and include several different doctors and health aides. All identifications, especially those referring to patients, have been removed.

Conversation 1

TANANA - Tanana calling (village).

VILLAGE - This is (village) back to Tanana. I've got negative medical traffic for you, over.

T - OK, did you ask about Darvon and breast feeding yesterday?

V - Roger on that, over.

T - Uh, generally, as a rule, we don't like people taking any medication when they are breast feeding, but there is no problem caused by taking Darvon when breast feeding. As a rule for advice, I wouldn't recommend people taking medicine while they're breast feeding, because some of it usually gets to the baby in the milk, but there is no known specific problem with it.

V - Roger on that. She's fairly much better yesterday and today. I just told her not to take that Darvon. I've got nothing else for you if you have anything for me.

T - No message today. This is Tanana clear with (village).

Conversation 2

T - Tanana calling (village).

V - (village) back to Tanana, I have one for you, over.

T - I didn't copy, you have one for me? over.

V - Roger, Roger, Roger, I have (female patient), age 11, have sore eye. She, her eye, the white part is red and now her eyelids is pussy, over.

T - Did she hurt her eye, did she get anything stuck in it, how does the clear part of the eye look? over.

V - It looks red. She woke up like that day before yesterday morning. over.

T - OK, is she on eyedrops now, or did she start? over.

V - She just came to clinic just awhile ago so I'm just reporting her now, over.

T - OK, I think she'll improve with eyedrops about every 4 hours while she is awake; while she's awake, I'd put eyedrops in that eye every four hours - have her hot pack and wash the eye when she gets up and is home from school and at nighttime at least. She should keep her fingers out of the eye - make sure she's not picking at it. If it itches or something, she's got to get a paper towel and put some water on it or a wash cloth and wipe off the outside of her eye. She can't pick at it with her hands, over.

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V - Roger, Roger. I talk to those stations last night about the eye clinic but they didn't give me yes or no and they said that they would see me later. I talked to (female patient's) mother, and she wanted her to go, but she would let me know later. I also talked to (female patient) and (male patient). He's got no problem with his new glasses so he said he doesn't have to go to the eye clinic . . . over.

T - OK, fine, we've got a few days to figure out who's coming, that's fine and (male patient) doesn't need to come up and its good they're thinking about it and we'll get an answer from him soon, over.

V - Roger, Roger, that's all I have OH, excuse me, day before yesterday (male patient), age 7, was playing in the yard, schoolyard, and fell. I don't know how he fell, but his mother brought him to me about 2:30 and I , uh, his arm was kind of hanging so I start feeling around and he looked like he had a broken collar bone so I put a bigger ace bandage on it and yesterday I checked him, it was loose, I tightened it again and he's doing OK, I check him this morning - he was OK, over.

T - OK that's fine, make sure that they understand that the figure of eight needs to stay on for longer than just until it's comfortable. It should stay on until the collarbone is non-tender - so that you can push around and it doesn't hurt and that it's stable so he'll need to wear it for a number of weeks probably at least 3, over.

V - Roger, Roger. That's what I told the mother that it should be on at least 3 weeks. Also yesterday, after your medical traffic, (male patient), age 13, came in and he got kicked right in the side - on the right side - shows a little bruise - but not real bad. He said it hurts when he puts his weight on it, but I had someone haul him home to his house and told him that he should stay in bed and I checked him after that and he was sitting up looking at comics and I asked him if it hurt, and he said not as long as he didn't step on it, and he could walk good, he just couldn't put his weight on it, over.

T - Where is the bruise? over.

V - Outside of left - outside between hip bone and knee.

T - OK, let's just see how he does - sounds like a pretty deep bruise, but if he's walking ok and the bone seems intact, uh, just have him contact you if things aren't clearing up. No other message here. Thank you.

V - Roger, Roger. I also checked (female patient) this morning and she's fine. She's using her hands and no problem now, over.

T - OK, that's good to hear. It's a lucky one. those injuries can be pretty bad. Did the teacher's wife take off to have a baby? over.

V - Roger, Roger. That's last week - she's over in Nome now, over.

T - OK, just trying to keep an idea of how many women close to term we have outside. That's fine - if there's no other traffic - this will be Tanana clear with (village).

Conversation 3

T - (Female patient) is doing well. Talked to some of the doctors and think she'll be in the hospital a total of six weeks since she was admitted. She's doing well as far as her leg goes but she has diarrhea but is under control. We wondered if you had any diarrhea in your village. They think it might be something she could have picked up up there. Has anyone else had a lot of diarrhea? over.

V - Roger, Roger. We have had a few cases of diarrhea. As I recall, I think (female patient) complained of this backache but she didn't have loose BM, over.

T - Roger, have the people been sick with diarrhea for a long time and have they had fevers or have they just been a one or two day thing? over.

V - Roger, Roger. I had (male patient) with diarrhea with high fever. He did have a high fever of about 103° and he did have diarrhea with it. He didn't get over until about one week, over.

T - How long ago did that person get over it and did he have any vomiting with it, over.

V - Negative on vomiting, he did not vomit, but he just didn't feel like eating for about 3 or 4 days - he did not eat. But he did have high fever and he is well right now.

T - Roger, Roger. Thanks a lot for the information. I don't think there are any more patients from (village) here and I will try to let you know how (female patient) is doing.

V - Did you say she will be hospitalized about 6 weeks?

T - They put a pin in the lower part of the leg just below the knee. It goes right through the bone. It doesn't cause her much pain, only a little bit. When it goes in there they freeze that part of the leg. They put that pin through so they can put some stretching on the bone that she broke so it will line up properly and heal properly and so she has to lie in bed with that lower part of her leg pinned so it will pull the upper part of her leg into the proper alignment and it takes about 6 weeks I am told, and that's - I expect she'll be in the hospital about a total of six weeks. Did you copy that? over.

V - Roger, Roger. We copy that. Now that she will be in the hospital six weeks, do the children go to school in Anchorage hospital? over.

T - Roger, yes they do. I don't know what kind of arrangement will be made for (her); she'll probably have to stay down in her room, but there is a school here and they do try to keep up somewhat with their school work, over.

V - The teacher here was thinking she could be sending some school work down to the children at the hospital. Do you think that would be OK if teacher sent work so they won't get too far behind? over.

T - I'll see what I can find out. It sounds like for the next one or two days (she) will probably be getting over this diarrhea. I'll talk with the teacher or whoever runs the school here and see what they say and try to let you know tomorrow. Is that OK? over

V - Roger, Roger. That sounds OK. (Village) clear.

Conversation 4

V - (Village) ... and I have one patient.

T - OK, go ahead, over.

V - (Female Patient), age 22, has a burn on left hand from Friday. Now it is infected and red around it.

T - She's had the burn for one week, over?

V - Yes, it's got infected now, over.

T - How big is it and how deep is it? over.

V - About 1 inch by 1 inch wide; it had blister but the blister turned to infection, over.

T - OK, how is she taking care of it now? over.

V - She's soaking it four times a day, over.

T - Has she used any ointment on it?

V - She's using vaseline on the burn, over.

T - OK, start soaking it in soapy water three times a day. Use your burn ointment on it three times a day after she washes it. Use a sterile covering on it to keep it clean. If she's not allergic to penicillin, start her on penicillin tablets one four times a day for the next three days. If it's not improving or it gets worse, let's talk about it on the weekend, over.

V - I'm out of penicillin tablets, over.

T - Tanana back to (village), please repeat, over.

V - I'm out of penicillin tablets.

T - OK, they were sent yesterday. I don't know if you will get them though. Use your penicillin suspension, uh, or do you have erythromycin tablets. I'd like to save your penicillin suspension. Do you have erythromycin tablets? over.

V - Yes, I have lots of that, over.

T - Well, start her on 1 tablet erythromycin four times a day along with the local care, washing and the ointment. Use the ointment only until the skin heals over and then stop using it, over.

V - It will be for how long? over.

T - Well, we'll see for three days now, until we see how she is coming along. She'll probably be on it for five days or until the skin is closed, over.

V - Roger, Roger.

T - Any other traffic? over.

V - No, this is all the traffic I have, over.

T - OK, thank you. This will be Tanana clear with (Village).

Attachments to Chapter VIII

VIII.1 St. Paul Doctor's questionnaire

VIII.2 Consultants' questionnaire

VIII.3 List of diagnoses of the consulted cases

Attachment VIII.1

St. Paul Doctor's questionnaire

(The figures refer to the number of times each square was checked on the 17 questionnaires filled out.)

TO BE DONE PRIOR TO RADIO CONTACT

1) Patient Name:____

2) Date:____________________ 3) Sex:__________

4) Initial Diagnosis:____

5) Severity Classification: (Realizing it is difficult to develop a universal severity classification, please check the most nearly descriptive category)

Class 1:	A simple question about an essentially asymptomatic individual, i.e., about medication, preventive management such as an immunization or the use of a household remedy.	1
Class 2:	Evaluation of a minor but symptomatic problem relating to a particular organ system, for instance URI or urinary tract infection with little potential to become a severe problem and little potential for mortality.	4
Class 3:	Evaluation of a moderately severe problem with potential for deterioration to a severe problem or to disability or chronic disease with moderate potential for mortality.	6
Class 4:	Evaluation of a problem producing severe symptoms or potential disability or a chronic process with a high potential for mortality.	5
Class 5:	Evaluation of a severe problem of life-threatening proportions.	1

6) Urgency Scale:

Class 1:	Not at all urgent - delay of 1 week would not effect outcome re. health status.	5
Class 2:	Some urgency - delay of a few days might result in significant worsening	8
Class 3:	Urgent - dalay of 24 hours affords substantial risk to patient	2
Class 4:	True emergency exists	1

7) Realizing there are many reasons for consultation, would you check the most nearly descriptive categories for consultation sought in this case:

	Primary Purpose	Also Significant	Not Significant
For diagnosis	6	3	7
For treatment	11	5	0
For preventive management	4	5	8
For patient reassurance	1	2	13
For patient motivation	2	2	11
For M.D. reassurance	5	8	3

8) (Prior to radio contact) regarding transfer:

a) patient probably doesn't need transfer /6/

b) patient should be transferred via weekly or biweekly airplane /7/

c) patient should be transferred via charter (as soon as possible) /2/

9) Service sought: (Surgery, medicine, etc.)______________________________

TO BE FILLED OUT AFTER CONTACT

1) Post Contact Diagnosis: ____________________

2) The service and/or individual sought was contacted:

Yes: ☐ No: ☐

3) The results of the consultation were:

a) No change in management recommended /4/

b) Diagnostic studies suggested /3/

c) Change or institution of treatment /5/

d) Transfer arranged or suggested /19/

4) Do you feel the consultation would have been materially improved by the addition of:

a) Facsimile transmission /2/

b) ECG or other physiological parameters /1/

c) Audiovisual transmission (slowscan T.V. one-way to Anchorage) /2/

NONE OR NO ANSWER /12

5) In rating the value of the contact in management of this patient:

a) Not at all valuable /0/

b) Minimal value /8/

c) Moderately valuable /9/

d) Very valuable /0/

6) Concerning predicted outcome relative to this patient the consultation had:

a) no effect on eventual outcome /1/

b) some effect probably only relative to symptoms probably not influencing future disability /10/

c) definite effect relating to future wellbeing or prevention of disability /4/

d) marked effect possibly life saving or prevention of major disability /1/

Attachment VIII.2

Consultants' Questionnaire

(The figures refer to the number of times each square was checked on the 29 questionnaires filled out.)

STANFORD UNIVERSITY
STANFORD, CALIFORNIA 94305

INSTITUTE FOR COMMUNICATION RESEARCH

CYPRESS HALL
Telephone
415/321-2300
Extension 2751

Dear Doctor ______________________:

You recently consulted with Dr. Ted Humphry of St. Paul Island via the ATS-1 satellite radio, concerning a patient whose name is written on the bottom of this letter.

We are evaluating the impact of the communication system via ATS-1 on the health care of the people served. In this instance, we are investigating the effectiveness of radio consultation between physicians.

The effectiveness of consultation to a remote site may be influenced by a variety of factors, including the resources available at the remote site, the seriousness of the condition and the diagnosis. There are also other factors which influence the incidence of consultations, such as the level of anxiety in both the patient and provider.

The accompanying data collection form asks for information along these lines. This information will be correlated with data collected by Dr. Humphry from his vantage point in the consultative interaction.

The form is a series of scales relating to complexity, urgency, the reasons for the consultation and the results of consultation. It should not take more than a very few minutes to complete, and your cooperation will be greatly appreciated. There is an attached stamped envelope which can be used to mail the form directly to me.

Sincerely,

William Fowkes
William C. Fowkes, Jr., M.D.
ATS-1 Evaluation Project

Patient's Name ______________________

Date of Consultation ______________

Diagnosis ______________________

1) Consultant's Name: ______________________________

2) Department: ______________________________

3) Date of consultation: ______________________

4) Diagnosis: ____

5) Severity Classification: (Realizing it is difficult to develop a universal severity classification, please check the most nearly descriptive category)

Class 1: A simple question about an essentially asymptomatic individual, i.e., about medication, preventive management such as an immunization or the use of a household remedy. /1/

Class 2: Evaluation of a minor but symptomatic problem relating to a particular organ system, for instance URI or urinary tract infection with little potential to become a severe problem and little potential for mortality. /4/

Class 3: Evaluation of a moderately severe problem with potential for deterioration to a severe problem or to disability or chronic disease with moderate potential for mortality. /16/

Class 4: Evaluation of a problem producing severe symptoms or potential disability or a chronic process with a high potential for mortality. /4/

Class 5: Evaluation of a severe problem of life-threatening proportions. /4/

6) Urgency Scale:

Class 1: Not at all urgent - delay of 1 week would not effect outcome re health status. /14/

Class 2: Some urgency - delay of a few days might result in significant worsening. /11/

Class 3: Urgent - a delay of 24 hours would have meant substantial risk to patient. /2/

Class 4: True emergency existed. /1/

7) Realizing there are many reasons for consultation, would you check the most nearly descriptive categories for consultation sought in this case:

	Primary Purpose	Also Significant	Not Significant
For diagnosis	/11/	/7/	/3/
For treatment	/17/	/10/	/0/
For preventive management	/6/	/3/	/6/
For patient reassurance	/2/	/5/	/6/
For patient motivation	/1/	/0/	/11/
For M.D. reassurance	/4/	/13/	/2/

8) The results of the consultation were:

a) No change in management recommended /4/
b) Diagnostic studies suggested /9/
c) Change or institution of treatment /10/
d) Transfer arranged or suggested /12/

9) Do you feel the consultation would have been materially improved by the addition of:

a) Facsimile transmission /2/
b) ECG or other physiological parameters /3/
c) Audiovisual transmission (slowscan T.V. one-way to Anchorage) /6/

NONE OF THEM OR NO ANSWER /1

10) In rating the value of the contact in management of this patient:

a) Not at all valuable /0/
b) Minimal value /1/
c) Moderately valuable /17/
d) Very valuable /10/

11) Concerning predicted outcome relative to this patient, the consultation had:

a) No effect on eventual outcome /3/
b) Some effect probably only relative to symptoms probably not influencing future disability /8/
c) Definite effect relating to future wellbeing or prevention of disability /14/
d) Marked effect possibly life saving or prevention of major disability /4/

Attachment VIII.3

DOCTOR-TO-DOCTOR CALL--St. Paul - Anchorage

Diagnoses of the Consulted Cases

	Specialty
G.I.Bleeding	Medicine
Fractured Tibia	Orthopedics
Fractured both Forearm bones	"
Adjustment reaction of Adolescence	Mental Health
Early dos. of Ant. Fontanel	Pediatrics
Foreign body in ear canal	Otolaryngology
Fractured radio and tibia	Orthopedics
Adjustment reaction of Adolescence	Mental Health
G.I. Bleeding	Medicine
Probably missed abortion	Ob-Gyn
Angina	Medicine
Epigastric pains	Surgery
Tonsillitis, fever, septicemia	Pediatrics
Coma, etiology	Medicine
Ischemic heart disease	"
Post auricular abscess, mastoiditis sebaceous	ENT
Iritis	Eye
Rectal Mass	Surgery
Chest pain pleural	Medicine
Ruptured globe	
Perforated gastric ulcer	Surgery
Rectal Mass	Surgery
Breast abscess	Ob-Gyn
Hyperventilation	Medicine
Herniatum	Pediatrics
Fractured arm	Orthopedics
Pancreatitis	Medicine
Pleuritis chest	"

Note: In two cases the diagnoses were not reported

Attachments to Chapter IX

IX.1 Description of the course

IX.2 CCU Course objectives

IX.3 CCU Course schedule

IX.4 CCU test and standards

IX.5 Tabulation of student responses to evaluation questionnaire

Attachment IX.1

Course Number: Medical Science 493

Title: Coronary Care Nursing (2+2)

Credits: 3

First Offered: Fall, 1972

Course Description:

This course will enable students to effectively care for coronary patients and will give them a working knowledge of coronary care units and equipment. Emphasis will be placed on detection, identification, and treatment of cardiac problems through signs and symptoms, and arrhythmias through electrocardiography. Anatomy, physiology, and pathophysiology of the cardiopulmonary system will be reviewed in detail as well as pharmacology specific to this field. CPR and electrical safety will also be discussed. Nursing intervention and care will be a continuing theme throughout the course. One two-hour lecture will be presented via satellite radio per week. Additional handouts and textbook reading will be assigned.

Estimated Enrollment: 20

Offered as Special Topics: Yes

Required for Degree: No

Replacing Required Course: No

Justification for Offering:

Due to the increasing knowledge, specialization and equipment evolving in this field, it is necessary to keep the nursing population informed and capable of handling cardiac problems. The remote area medical personnel are the first and therefore the best people to detect and treat cardiac problems.

Prerequisites:

Course is open to registered nurses, licensed practical nurses, medics, physicians assistants, and other health workers with proper medical background. Consent of instructor required for prospective registrants other than those specified.

Instructors: Richard Lyons, M.D. (Chairman)
Betsy Ovitt, R.N. (Coordinator and Instructor)
Guest Lecturers
Consultation of Nancy White R.N., Clinical Nurse Specialist, Washington-Alaska Regional Medical Program

Course Outline: Attached

Texts: Andreoli, Hunn, Zipes & Wallace, Comprehensive Cardiac Care, C. V. Mosby Co., Second Edition.

Additional Student Materials: Folder from American Heart Association
Syllabus
Handouts

Methods of Examining and Testing:

A midterm and final exam proctored by the group leaders will each contribute 25% toward their grade. Quizzes before each week's lecture will accumulate to another 25%. The final quarter will be based on their additional assignments from each topic. A letter grade will be issued at the end of the course.

CCU COURSE OBJECTIVES

1. To develop a working knowledge of the anatomy, physiology, and pathophysiology of the cardio-pulmonary system.

2. To increase knowledge and understanding of the causes, complications, and treatment of patients with myocardial infarction and disorders of the heart beat.

3. To increase knowledge and skills in recognizing and interpreting electrocardiography, especially the recognition and treatment of lethal disorders of the heart.

4. To be able to properly use electronic monitoring and defibrillating equipment.

5. To develop skills in early recognition and treatment of cardiac complications.

6. To be familiar with CPR principles and practice and to confidently initiate them in an emergency situation.

7. To develop an understanding of the basic drugs and their desired and toxic effects in relation to the cardiac patient.

8. To develop a basic understanding of the laboratory tests pertaining to cardiac and resperatory disease and their significance and interpretation as used for the cardiac patient.

9. To develop a working knowledge of fluid and electrolyte balance in relation to the coronary patient.

10. To be aware of the respiratory system as a separate entity and as an integral part of the cardio-pulmonary system; and to be aware of the function and use of available respiratory equipment.

11. To develop a basic knowledge of electrical safety as applied to the hospital setting.

12. To be able to develop and apply a working knowledge of all aspects of patient care in relation to the cardiac patient.

13. To be aware of the fact that knowledge and skills gained in this course can and should be applied with confidence in any type hospital setting.

Attachment IX.3

SCHEDULE FOR CORONARY CARE COURSE, FALL, 1973

Week	Topics
09/27	Introduction to course. Review of the anatomy and physiology of cardio-pulmonary system.
10/04	Electrocardiography and Monitoring. Normal EKG configuration. Relationship of EKG to heart activity. Principles of taking proper EKG. Proper monitoring of the pt. How to achieve it.
10/11	Pharmacology. Discussion of action, uses, and toxic effects of cardiac glycosides, antiarrhythmic, sympathomimetic, anticholinergic, anticoagulent, diuretic and miscellaneous agents.
10/18	Uncomplicated MI. Coronary heart disease, definition and implications. Presenting signs and symptoms of angina, MI and coronary insufficiency. Lab tests and EKG used for diagnosis. Treatment in the uncomplicated course for pt. Nursing care.
10/25	Complicated MI. Presenting signs and symptoms and Rx for congestive heart failure, cardiogenic shock, embolism, aneurysm and tamponade. Nursing care.
11/01	Sinus arrhythmias. Identification and treatment of cardiac arrhythmias which arise in the sinusnode.
11/08	Atrial arrhythmias. Identification and treatment of cardiac arrhythmias which arise in the atria.
11/15	Junctional (Nodal) arrhythmias. Identification and treatment of cardiac arrhythmias which arise in the A-V junction (node). Bundle Branch Block.
11/29	Ventricular arrhythmias. Identification and treatment of cardiac arrhythmias which arise in the ventricles.
12/06	Heart Block. Identification and treatment of heart block. Pacemaker equipment. Nursing care of patient with pacemaker.
12/13	CPR - Electrical Safety. Principles in using CPR. Principles of electricity and electrical safety in the hospital setting.
12/20	Respiratory System. Review of physiology. Respiratory system importance in cardiac care. Inhalation therapy equipment and uses.
01/10	Epidemiology, Rehabilitation of Coronary Patients. Learning needs of pt.
01/17	Congenital defects. Signs and symptoms. Treatment.
01/24	Open. Questions and review.

Attachment IX.4

Description of Washington/Alaska Regional Medical Program CCU Test and Standards

The tests used by Washington/Alaska R.M.P. for pre and post testing contain 100 items each which are weighted in the following fashion:

CCU Concepts	1)	Summarized as CCU Concepts
Anatomy and Physiology	3)	
The Classic MI	8)	
Diagnostic Tests	5)	
Rehabilitation	8)	
Complications of an MI (excluding arrhythmias)	13)	Summarized as Complications
Electrocardiography	8)	Summarized as Arrhythmias
Equipment and Safety	3)	
Arrhythmias	19)	
Chemical Therapy	13)	Summarized as Chemical Therapy
Other Therapy (i.e. pacing, resuscitation)	19)	Summarized as Other Therapy

The pre and post tests are of equal difficulty according to standard statistical measures. The student answers each question with what he supposes to be the correct answer and in addition rates certainty of that answer on a scale from one to three or absolute certainty to guessing. The computer summary of the students' scores then computes not only how many questions were answered correctly but also the number of questions that the student was certain about and how many which he or she says she was certain about that she actually answered correctly. Thus the tests can measure three areas of potential change from pre to post course:

1. Change in knowledge (right/wrong score)
2. Change in expressed certitude and guessing
3. Change in ability to evaluate the students' knowledge about CCU nursing

These three factors are recorded for the overall exam as well as for solid content area within the exam for each student and each class taking the exam. (See Attachment VI)

The regional mean for the pre-test is 32%; the regional mean for the post test is 53%. The reliability coefficient of these exams when administered to a group of ten or more individuals range from 0.89 to 0.95.

Attachment IX.5

Tabulation of Student Responses to Course Evaluation Questionnaire

A. Course Content

1. In general, do you feel the course content was:

		1	2	3	4	5	
a.	hard to follow	1	3	4	4	3	easy to understand
b.	impractical		1	3	6	5	applicable
* c.	too basic			6	8	1	too advanced
* d.	too much material for you to handle		4	9	1	1	not enough new, useful information

Comments:

B. Lectures

1. In general, did you consider satellite radio lectures to be:

a.	repetitious			2	3	10	informative
b.	unnecessary			2	3	10	helpful
c.	confusing		2		9	4	organized
* d.	too short			8	5	2	too long
* e.	too basic		1	7	6	1	too technical

Comments:

C. Visual Aids (Slides)

1. In general, do you consider that the slides were:

a.	unnecessary	1	2	2	1	9	helpful
b.	inappropriate to lecture			4		11	appropriate to lecture
c.	too much trouble to show	1	3	3	1	7	worthwhile effort
d.	repetitious		1	3		10	added useful input

Comments:

D. Question Times

Was time allotment for questioning during lecture:

		1	2	3	4	5	
a.	unnecessary			1	6	8	helpful
*b.	too short a period	2	1	10		1	too long each period
*c.	too few periods	1	3	9	1		too many periods
d.	confusing		1	1	2	11	worthwhile

Comments:

E. Syllabus

In general, do you feel syllabus was:

unnecessary			1		14	necessary

Were extra readings in syllabus:

not helpful		1	1	2	11	helpful

Were lecture outlines:

too general		3	2	3	7	detailed enough
confusing	1	1	2	4	7	easy to follow
did not tell important points	1	1	2	6	6	highlighted pertinent points
not a help with notetaking			1	4	10	helped with notetaking

Were study questions:

useless			3	6	6	helpful
adequate	4	4	3	3	1	too difficult
pointless			1	5	9	helped bring course together

F. Instructor

In general, was the instructor's presentation:

	1	2	3	4	5	
monotonous		2	1	4	8	interesting
mumbled	1		1	3	10	clear
*too fast	1	7	5	1	1	too slow
difficult to follow		3	2	5	5	easy to follow

G. Radio Transmission

Was transmission:

garbled	2	2	3	5	3	clear
full of static	3		5	2	5	understandable

Eleven of the participants indicated that the radio transmission failed in their area. The frequency of this occurrence varied:

frequently	2
several times	3
twice	2
once	4
none	3
can't remember	1

Ten indicated that the transmission was sporadic during lectures.

Eight of the participants indicated that they missed a complete lecture.

The ability to hear the question periods varied. Students indicated they could hear the questions clearly:

most of the time	6
sometimes	3
couldn't hear clearly	6

Areas that they had consistent difficulty hearing were as follows:

Barrow	2
Juneau	5
Nome	1

H. Tests

In general, were quizzes:	1	2	3	4	5	
not helpful			1	4	10	helpful
too easy		1	9	3	2	too hard
too many			13		2	too few

Twelve indicated that the area in which the satellite radio is placed was adequate for this type of educational program. Two felt it was not.

Advantages of this course were stated as follows:

continuing education credits	5
means of updating knowledge	2
means of providing education to remote areas	2
a better way to use teachers	1
a stimulus for learning	2
long period of time to absorb material	1

Disadvantages of this course were stated as follows:

poor radio transmission	2
no pertinent patients to apply knowledge	3
no personal contact with instructor	2
lack of visual stimulation	2
not enough EKG	1
not enough material	1
poor mail service	1

Fourteen indicated that they would definitely take another satellite radio course; one stated maybe. Most indicated that they would take a satellite course with video transmission. The advantages of this were stated as follows:

would be able to see the instructor	2
more stimulating	2
visual aids	4

Ways to improve this course were stated as follows:

increase number of visual aids	2
have contact with a CCU	1
more rhythm strips	1
more reference materials	1
more information on EKG & MI	1
shorter length	1
more practical to patient population	1

Additional courses requested for satellite radio were as follows:

death and dying	2
pediatrics	6
drug abuse	2
inhalation therapy	1
refresher courses	1
emergency care	2
pharmacology	1
pulmonary disease	1
obstetrics	2
surgery	1
anything	2
trauma	2
alcoholism	1
stress	1
communicable disease	1

Attachments to Chapter XI

XI.1 Comparison of Anik and Intelsat Satellites

XI.2 The Satellite System Design Program: A Method of Satellite Communications System Optimization

XI.3 Alaska Public Health Service Units Community Profile

XI.4 Parameters and Costs of the Least-Cost Satellite System Configuration

XI.5 The Point Reyes Station Tests

XI.6 Specifications for a Small Satellite Communications Earth Station

XI.7 Central Manual Telephone Exchange

XI.8 Alaskan Indian Health Service Satellite Communication Station

XI.9 Alaska's Communications Needs and Potential Solutions Utilizing Satellites

XI.10 Review of RCA Small Station Request for Proposal

ATTACHMENT XI.1

Comparison of Anik and Intelsat Satellites

The Canadian satellite and Intelsat IV satellites both have antenna beams which can cover Alaska. Both are operational satellites in orbit now and thus could serve as the basis for an Indian Health service communications system.

To compare the two systems, a link performance-cost analysis was made. While the link performance analysis was solid, it should be recognized that the cost comparisons are rudimentary. Both the commercial satellites are subject to the pressures of competition and charges for use of their transponders varies from time to time. The costs of the ground systems are also necessarily approximate. The intent is to give guidance on the total cost, but more importantly, to identify major differences, if any, between the two satellites.

The cost calculations have used the following assumptions:

1) The capital cost of the ground systems includes the cost of power amplifier, cost of antenna, cost of pre-amplifier and and a constant sum of $15,000 for each station to cover the cost of modulators, demodulators, down-converters, up-converters, power supplies, cable, etc.

2) The capital cost of the above items is based on purchase of 20 to 50 units.

3) The ground station capital cost is converted to an equivalent analyzed cost by dividing by 6; i.e., annual cost = 0.17 x capital cost. This is equivalent to an 8% maintenance cost and a 6% cost of money with a 20 year lifetime.

4) The satellite charge is assumed to be $3 million per transponder year for either satellite (this figure would be subject to negotiation).

The power received for this price is assumed to be 0.40 of the satellite's saturated transponder power. (The transponder must be backed off from its maximum output at least 4 dB to avoid mutual interference between channels.)

The cost for each channel is assumed to be proportional to it's use of this total available power.

$$\text{channel cost/yr} = \$3{,}000{,}000 \times \left(\frac{\text{power per channel}}{0.4 \times \text{power saturated}}\right)$$

5) Ten stations share each channel on the average; annual cost per station is:

$$\text{channel cost per station} = \frac{1}{10} \times \text{channel cost/yr}$$

6) Total annual cost per station is the sum of ground station and satellite cost.

The link calculations made here are assuming worst case conditions. It is assumed that the satellite transponder beams are not pointed directly at Alaska and the ground stations are located close to the beam edge. For Anik, which is pointed towards central Canada, the beam center Effective Isotropic Radiated Power (EIRP) is 38 dB which gets down 7 to 8 dB before mainland Alaska is covered, even though the Aleutian Islands and the Alaskan peninsula are not covered by the satellite beam. Therefore, the satellite EIRP is down to 30-35 dB for the Alaskan region.

The Intelsat IV spot beam is pointed towards the west coast area of the U.S.A. and the satellite EIRP is down by 5-6 dB in the direction of Alaska. If the spot beam was pointed at Alaska, the whole area would be covered by the beam. An advantage in using the Intelsat IV transponder is in being able to adjust the gain. Intelsat IV has 12 transponders with 8 gain steps; Therefore, if one of its transponders was available for use in Alaska, the gain could be adjusted to the highest gain step, thus making possible the use of a less powerful transmitter at the ground station.

The costs have been derived in terms of the parameter C/kT, the carrier-to-noise ratio that will result from the system being considered. For any given technique C/kT determines the quality of the resulting signals. Values of 45 to 55 dB are typical for voice services. Lower than 45 dB is usually good only for low rate data; higher than 55 dB is used for multiple channels of voice, high speed data, facsimile and television.

For each combination of equipment the performance, C/kT, and cost have been calculated for the two satellites. The results are presented in Table A. Two example link calculations are given in Tables B and C; these correspond to station combinations (Table A) "O" with Intelsat IV, and "Q" for Anik.

The results of these tables are plotted in Figure 1 a and b. Solutions involving 10', 15', and 20' antenna diameters are shown with different symbols. As can be seen, in the C/kT range of around 50 dB, the two satellites both offer an annual cost of about $4,500 to $6,000. Thus for the assumptions made, the two satellites are comparable. Either could be chosen for the Health Service needs with no major cost disadvantage.

Table A

Station Cost and Performance

				Intelsat IV		Anik	
Code	Antenna Diameter	Pre-Amp Used	Transmitter Power	C/kT dB/Hz	Cost ($K)	C/kT dB/Hz	Cost ($K)
A	20'	Par-amp (Noise temp = 90°K)	100 W	62.46	12.31	65.49	23.08
B	20'	TDA (Noise temp = 600°K)	100 W	58.2	11.31	60.93	20.08
C	20'	Par-amp	50 W	59.45	9.15	62.49	14.54
D	20'	TDA	50 W	55.23	8.15	57.92	13.54
E	20'	Par-amp	20 W	55.475	7.16	58.5	9.32
F	20'	TDA	20 W	51.25	6.16	53.05	8.32
G	20'	Par-amp	10 W	52.46	6.5	55.5	7.57
H	20'	TDA	10 W	48.24	5.5	50.94	6.57
I	20'	Par-amp	5 W	49.45	5.92	52.49	6.45
J	20'	TDA	5 W	45.23	4.92	47.93	5.45
K	15'	Par-amp	100 W	57.96	8.47	60.79	16.53
L	15'	TDA	100 W	53.42	7.47	56.04	13.53
M	15'	Par-amp	50 W	54.95	6.40	57.78	9.43
N	15'	TDA	50 W	50.413	5.40	53.03	8.43
O	15'	Par-amp	20 W	50.97	5.06	53.8	6.27
P	15'	TDA	20 W	46.43	4.06	49.05	5.27
Q	15'	Par-amp	10 W	47.96	4.61	50.79	5.22
R	15'	TDA	10 W	43.42	3.61	46.04	4.23
S	15'	Par-amp	5 W	44.95	4.14	47.78	4.443
T	15'	TDA	5 W	40.413	3.14	43.03	3.443
U	10'	Par-amp	100 W	51.305	6.08	53.96	8.77
V	10'	TDA	100 W	46.51	5.08	49.06	7.77
W	10'	Par-amp	50 W	48.29	4.79	50.95	6.11
X	10'	TDA	50 W	43.5	3.79	46.05	5.11
Y	10'	Par-amp	20 W	44.315	3.92	46.97	4.45
Z	10'	TDA	20 W	39.52	2.92	42.07	3.45
AA	10'	Par-amp	10 W	41.30	3.62	43.96	3.89
AB	10'	TDA	10 W	36.51	2.62	39.06	2.89
AC	10'	Par-amp	5 W	38.29	3.23	40.95	3.36
AD	10'	TDA	5 W	33.50	2.23	36.05	2.36

Table B

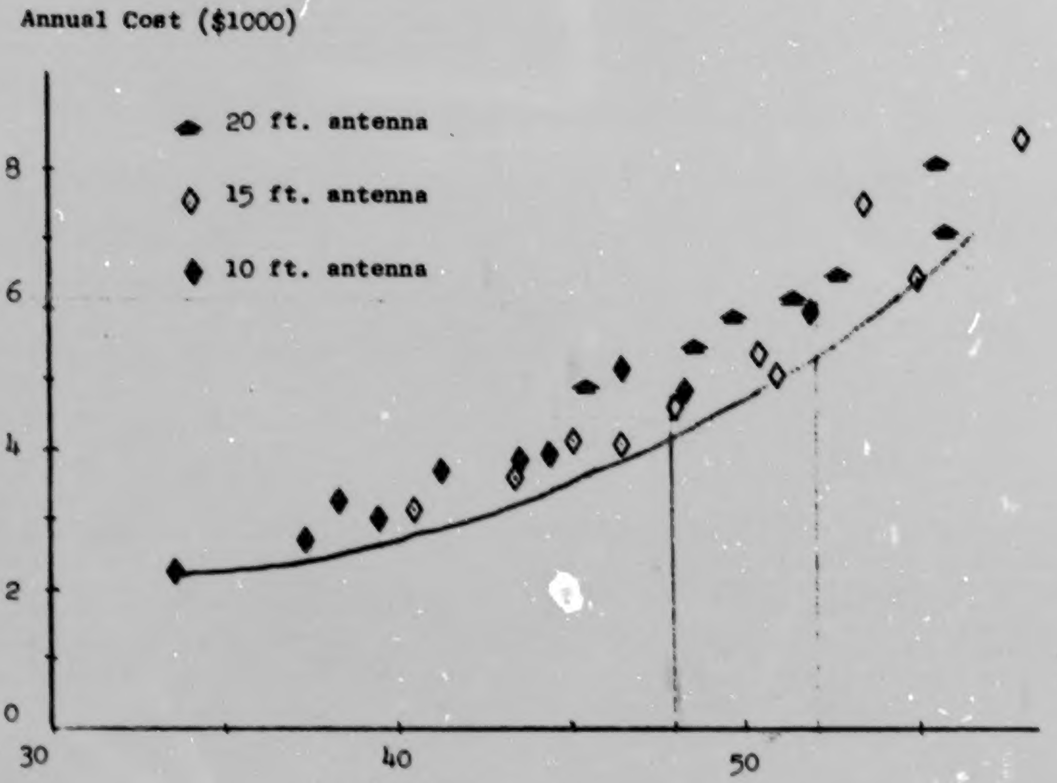
Intelsat IV-Link Calculations for Station "O"

```
                        ****LINK PARAMETERS****

UP-LINK FREQ (GHZ)                    6
PATH LENGTH TO SAT (KM)               41173.

PATH LENGTH TO RX (KM)                41173.
DOWN-LINK FREQ (GHZ)                  4

SAT G/T ON-AXIS (DB/DEG K)           -14.6
SAT IM REL TO SATUR EIRP             -15
SAT GAIN (DBW/DBW/SQ M)               116.5

                        ****LINK CALCULATIONS****

TX PWR (DBW)                          13.0103
TX ANT DIAM (FT)                      15
TX ANT GAIN (DB)                      46.4843
TX LINE LOSS (DB)                     1.5
TX POINT LOSS (DB)                    .5
UP-LINK RAIN LOSS (DB)                1
FLUX AT SAT (DBW/M SQ)               -106.787
SAT RX OFF-AXIS LOSS (DB)             2.5
C/KT UP (DB)                          67.6899

ON-AXIS EIRP (DBW)                    7.21294
OFF-AXIS SAT TX LOSS (DB)             4
RAIN/ATMOS LOSS, DOWNLINK (DB)        1.5
RX POINT LOSS (DB)                    .3
RX LINE LOSS (DB)                     .8
PRE-AMP NOISE TEMP (DEG K)            90
SYST NOISE TEMP W/RAIN (DEG K)        234.188
RX ANT DIAM (FT)                      15
RX G/T (DB/DEG K)                     19.2674
C/KT DOWN (DB /HZ)                    51.697

C/IM NOISE DENSITY (DB/HZ)            59.7335

C/KT TOTAL (DB/HZ)                    58.9696
RF BW (KHZ)                           15
CNR IN RF BW (DB)                     9.20865
AUDIO BW (KHZ)                        3.4
WTD TTNR (DB)                         21.5416
ANNUAL COST ($K)                      5.06029
```

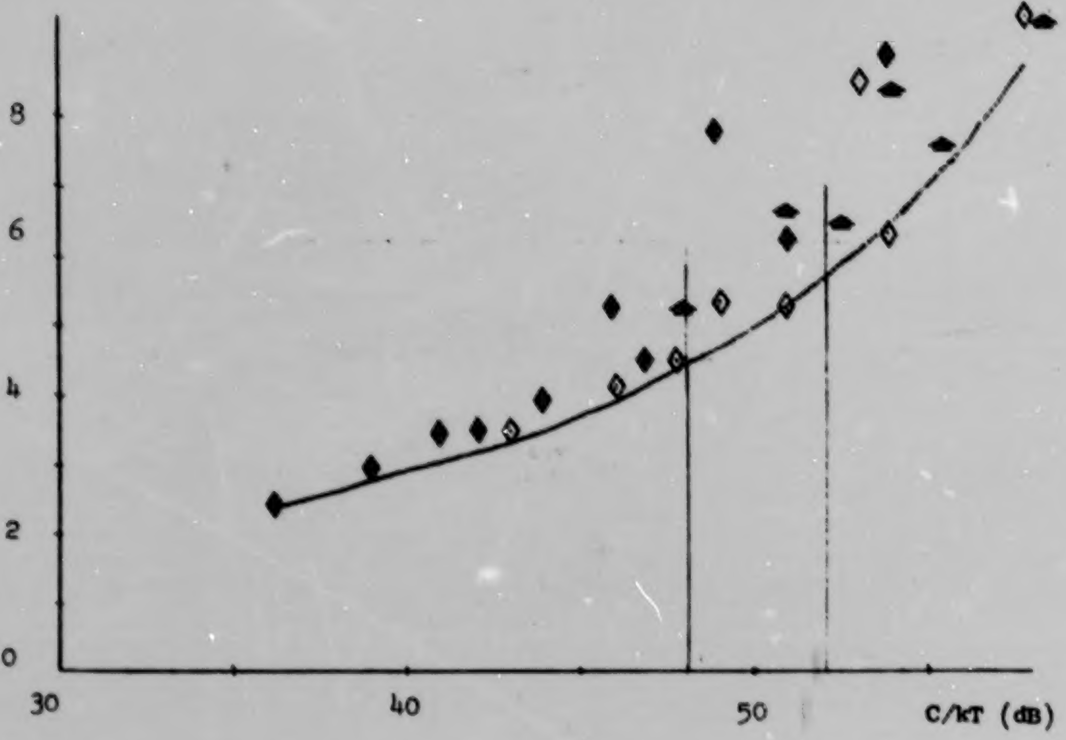
Table C

Anik-Link Calculations for Station "Q"

```
                    ****LINK PARAMETERS****

UP-LINK FREQ (GHZ)                 6
PATH LENGTH TO SAT (KM)            41173.

PATH LENGTH TO RX (KM)             41173.
DOWN-LINK FREQ (GHZ)               4

SAT G/T ON-AXIS (DB/DEG K)        -7
SAT IM REL TO SATUR EIRP          -15
SAT GAIN (DBW/DBW/SQ M)            119

                    ****LINK CALCULATIONS****

TX PWR (DBW)                       9.99999
TX ANT DIAM (FT)                   15
TX ANT GAIN (DB)                   46.4848
TX LINE LOSS (DB)                  1.5
TX POINT LOSS (DB)                 .5
UP-LINK RAIN LOSS (DB)             1
FLUX AT SAT (DBW/M SQ)            -109.797
SAT RX OFF-AXIS LOSS (DB)          2.5
C/KT UP (DB)                       72.2796

ON-AXIS EIRP (DBW)                 6.70264
OFF-AXIS SAT TX LOSS (DB)          4
RAIN/ATMOS LOSS, DOWNLINK (DB)     1.5
RX POINT LOSS (DB)                 .3
RX LINE LOSS (DB)                  .8
PRE-AMP NOISE TEMP (DEG K)         90
SYST NOISE TEMP W/RAIN (DEG K)     234.188
RX ANT DIAM (FT)                   15
RX G/T (DB/DEG K)                  19.2674
C/KT DOWN (DB /HZ)                 51.1867

C/IM NOISE DENSITY (DB/HZ)         61.7232

C/KT TOTAL (DB/HZ)                 50.7879
RF BW (KHZ)                        15
CNR IN RF BW (DB)                  9.02699
AUDIO BW (KHZ)                     3.4
WTD TINR (DB)                      21.3601
ANNUAL COST ($K)                   5.21923
```



(a) Intelsat IV Satellite



(b) Anik Satellite

Figure 1 Annual Cost of Ground Stations vs C/kT

ATTACHMENT XI.2

The Satellite System Design Program: A Method of Satellite Communications System Optimization

As part of NASA Grant 05-020-659, Stanford has developed a program to optimize satellite system designs. This program is described in Chapter II of a report entitled "The Use of Satellites in Meeting the Telecommunications Needs of Developing Nations" by William C. Mitchell, Research Assistant, Stanford University. This attachment is Chapter II of the above report. All appendices and chapters referenced in this attachment apply to the report from which it was taken which is available upon request.

This program was used in the assessment of alternative approaches to satisfy the communications needs of rural Alaska.

THE SATELLITE SYSTEM DESIGN PROGRAM: A METHOD OF SATELLITE COMMUNICATIONS SYSTEM OPTIMIZATION

A. INTRODUCTION

The first sections of this chapter contain a description of a computer program that optimizes the system design of a satellite communications system for national network telephony. Any communications situation for which the potential of satellite communications is to be assessed may be described in terms of the input parameters of this program. When so described and submitted to the program, the minimum-cost system configuration that meets all of the indicated service requirements will be calculated.

In the next section, a typical design situation is simulated using estimates of the long-distance traffic requirements for Canadian domestic telephone service and the results are summarized. The last section of the chapter presents what shall be called the Satellite Facility Matrix. This matrix is obtained from a series of program runs that determine the sensitivity of the earth-station design parameters to the number of earth stations and to the average requirements, or demand, for telephone circuits per station. A matrix of similar form showing the least-cost terrestrial facility as a function of facility length and circuit demand is given in Chapter III. Both matrices find application in the method of overall national telecommunications system planning that is described in Chapter IV.

B. DESIGN APPROACH

1. Necessity for Computer Design Program

It was determined at the outset that the design method to be devised must take into account the effect of all of the major equipment design parameters, as well as the time value of money and any increases in both the number of earth stations and the demand for circuits at each earth station during the study period. The method should not, a priori, assume any one parameter to be insignificant or arbitrarily assign to any an "optimum" value. In view of the fairly large number of interdependent variables associated with the systems design of a satellite communications system, it became an obvious necessity to take advantage of the capability of a large digital computer.

2. Minimum Cost Index

Inasmuch as the major concern of most planners is that, for a required level of service, the system they implement maintain a low budget profile, system optimization is with respect to total system cost, as given by the present worth of annual costs. Total system cost is obtained as the sum of the present worth costs of: 1) installed capital equipment, 2) operations and maintenance of the equipment for the duration of the study, and 3) land and building for earth stations.

The present worth of annual costs was chosen as the index of comparison for three reasons. First, it takes into account the time value of money which if neglected would imply that borrowed capital, either equity or debt, may be repayed with no interest charges. Obviously, free money is not a characteristic of the real world and decisions based on such a concept would introduce serious error. Second, the present worth of annual costs include all the costs incident to the satellite facility during the period of study -- not just the initial cost of equipment. Third, much of the literature dealing with engineering economy in telecommunications and almost all of the present long-range planning of many large telephone operating companies is in terms of the present worth of annual costs. It is expected, therefore, that the planning agencies of developing nations will be familiar with and have confidence in the use of this cost index.

3. Channelization and Signaling Equipment

Since the cost of satellite system terminal equipment (channelizing and signaling equipment at the earth stations) is not affected by the values of the earth-station parameters that are subject to optimization (viz., the antenna diameter, the station noise temperature, and the power rating and output back-off of the power amplifier), no particular benefit would be derived from including this cost -- a constant -- in the optimization program. Therefore, total system cost, as just described, does not include the cost of terminal equipment. As will be seen in Chapter III, the costs of the terrestrial facility alternatives to satellite transmission are also given without including the cost of the terminal equipment.

4. Volume Purchase Discount

All cost calculations for the ground segment include the standard 92% learning curve to account for economies of scale on equipment purchased during the same calendar year. That is, for N units in any given year, the per-unit cost, as a fraction of the single item cost, is:

CPU/SIC = 0.92**(log(N)/log(2))

where CPU is the cost per unit, SIC is the single item cost, and ** denotes exponentiation.

C. MODEL DEFINITION

The major questions concerning model definition are:

a) What type of multiple-access scheme is most appropriate?

b) What type of rf modulation should be used?

c) If FDMA is chosen, what must be said about the frequency assignment plan?

d) How many distinct "sizes" of earth station (in terms of the earth-station figure of merit, G/T) should be considered?

e) In what form should the demand for circuits be given and how should an increase in demand over time be represented?

They shall be considered in order.

1. Multiple Access

Several authors have investigated the merits, insofar as possible, of various multiple-access schemes. (2,6) The concensus, at the present time, is largely in favor of Frequency Division Multiple Access (FDMA) for operation with low-cost earth stations for three main reasons. First, the peak power of the earth-station power amplifier for FDMA is less than that for Time Division Multiple Access (TDMA) by a significant margin in terms of cost. Second, the system synchronization necessary with TDMA is a major cost item and not presently compatible with low-cost stations. And, third, the guard time between users for systems with more than about 25 earth stations reduces the efficiency of satellite utilization below the levels that may be obtained using FDMA.

2. RF Modulation

The type of rf modulation was of secondary concern as far as program development was concerned, since program trade-offs would be based on link calculations and these are essentially independent of the type of modulation -- once, of course, the transmission characteristics for the particular type are specified. (For much the same reason, it is possible to use the program in the design of TDMA systems even though the primary development effort was accomplished with FDMA systems in mind.) Nevertheless, it is important from the total system point of view where satellite and terrestrial facilities are being compared on a cost basis.

The literature and extensive calculations done here at Stanford indicate that frequency modulation is at least as sparing of power and occupied bandwidth as other types of modulation. (7,8,9,10). In addition, where comparison was possible using commercially available equipment, the cost differences favored FM. It is felt, however, that the cost differences may narrow as the demand for and the production of digital equipment increases.

3. Frequency Assignment Plan

A frequency assignment plan is, essentially, the manner in which any station obtains access to the system. For the purpose of this study, it is of concern mainly where the satellite is bandwidth limited. In such a case, a trade-off would be made between the simpler, less costly (in terms of earth-station equipment), relatively inefficient (in the use of satellite bandwidth) plans and the increasingly complex plans that, correspondingly, are increasingly costly and more efficient in their use of bandwidth.

As is appropriate for operation into low-G/T earth stations, the satellite is treated herein as a power limited amplifier. When it is the satellite power that is limited, the frequency plan is of secondary importance since it may be assumed that sufficient bandwidth is available for whatever plan is adopted and, in contrast to the required number of assignable satellite frequency slots, the total satellite power requirement is only weakly sensitive to the frequency assignment plan.

The assignment plan is (or should be) transparent to the users (i.e., they cannot distinguish among plans from any effect on service quality) and would not influence the calling rate or traffic pattern. At any moment, therefore, the number of calls in progress, and consequently the required satellite power, would be independent of the plan.

This statement may need to be modified when, as is usual, the required satellite power is divided among several transponders. If it happens that particular traffic groups are wholly constrained to single transponders the total required power of the satellite could no longer be shared, as needed, among groups. Where there is only one large transponder, a very active traffic group could draw on power normally used by other groups (it is improbable that all groups would be very active simultaneously). With groups constrained to single transponders, each transponder must be capable of the maximum power for its group.

For a fully variable plan (each station may transmit and receive in any of the assignable frequency slots) this effect can be made negligible. Accordingly, total required satellite power calculations are based on the use of a fully variable frequency assignment plan. If other than a fully variable plan is used, the required increase in satellite power may be accommodated with a multiplier, the value of which must be determined from available traffic and frequency plan information and set as part of the input to the program.* The multiplier should be set equal to one for a fully variable plan. In the program runs reported on in this paper, it is given the value of 1.15. (It is judged extremely unlikely that a value larger than 1.15 would occur.)

Having accounted for the effects of the frequency plan on total required satellite power, it is assumed that the particular manner of power division among transponders does not further influence the efficiency with which the power is used. Therefore, no specification of transponder power is necessary.

In connection with the frequency assignment plan, the question arises as to whether multi-channel-per-carrier operation (mc/co) should be used among stations with comparatively large traffic requirements. An investigation showed that single-channel-per-carrier operation (sc/co) is more efficient with respect to bandwidth when the traffic volume between any two earth stations requires fewer than 300 circuits and that sc/co is also more efficient with respect to power, when voice activation of the single-channel carriers is used, for all traffic volumes that were investigated (up to 960 circuits). (See Appendix A.) For example, in providing 60 circuits between earth stations, sc/co achieves a 30% savings in bandwidth and as much as a 65% savings in power relative to mc/co. Therefore, sc/co is used at all stations.

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*The power penalty for transponderization may be approximated as the percent increase in active channels. (An active channel is one over which a voice signal is actually being transmitted.) For example, a single transponder with 1000 assignable frequency channels would, for a probability of 0.01 that the number of active channels is not exceeded and a probability of 0.40 that a busy channel is active, require enough power for 436 simultaneously active channels. By contrast, under the same conditions, a transponder with only 250 assignable frequency channels would need 118 active channels. The percent increase in active channels would, in this case, be ((4•118 - 436)/436)•100%, or 8.2%.

4. Number of Station Sizes

Originally, there were to be three possible station sizes (station size is synonymous with station G/T), corresponding to low-, medium-, or high-density traffic requirements at any given location. From a preliminary version of the program, it was noticed that a single size of station was serving for both low and medium densities. A 10 to 15 ft. antenna was the optimum even for stations whose circuit requirement grew to be as high as 30 to 40 circuits over a 15 year study period. This fact is also indicated by a table (Table 2-6) which is shown in the last part of this chapter. Accordingly, in the final version of the Satellite System Design Program, this finding is incorporated as an apriori conclusion that two distinct sizes of earth station is the optimum, or least-cost number of sizes for most national telephony satellite systems. Unusual demand situations are easily recognized. In such a case, a specific investigation of the suitability of more than two sizes of earth station could be made.

5. Demand Characterization

The international unit of demand for telephone circuits is the erlang. The demand in erlangs is equal to and synonymous with "the average number of calls in existence during the busy hour." During the busy hour, the average ratio of lost calls to total calls offered is known as the "grade of service." Usually given as a probability, it may be written as P.01, P.03, or P.001. A P.01 grade of service, for instance, means that one call out of every 100 offered during the busy hour is lost.

The erlang may be used in referring to the traffic offered by individual subscribers as well as that offered by groups. Indeed, the number of erlangs of traffic offered by a group of subscribers is the sum of the erlangs offered by each individual of the group. Or, the number of erlangs offered to a satellite by several earth stations is the sum of the erlangs offered by the individual stations, after elimination of duplicate counting. (The erlang is a measure of circuit -- two-way conversation -- requirements. Therefore, when two earth stations each experience a demand of say E erlangs for circuits for traffic between them, the satellite will be offered E erlangs of traffic, not 2 times E erlangs.)

The number of circuits required to satisfy a given demand in erlangs at a given grade of service is not proportional to the demand but is given by what is known as the Erlang B formula, as follows:

$$B = \frac{\frac{E^n}{n!}}{1 + E + \frac{E^2}{2!} + \ldots + \frac{E^n}{n!}}$$

where B is the loss probability, $\underline{n}$ is the number of circuits required, and E is the traffic demand in erlangs.

The total number of circuits required at the satellite is not, then, the sum of the number of circuits required at each earth station. For this reason, it was decided to describe the demand at each station in terms of erlangs and then convert to the required number of channels. It is apparent that converting erlangs to circuits would be an iterative process involving the repeated calculation of factorials if the Erlang B formula were used. To avoid this time-consuming process, a simplified formula has been devised that gives the conversion directly. (See Appendix B.)

D. PROGRAM DESCRIPTION

1. Overview

As stated earlier, this program was developed to determine the minimum-cost satellite communications system for telephony using two types or sizes of earth station under a variety of service requirements. The nature of the problem is that of constrained minimization. The constraints are those of circuit quality, circuit demand, length of study period, satellite coverage area, whether and to what extent satellite power is shared with other users, and so forth. The method of optimization may be described as a branch and bound technique or could be termed "educated enumeration." Both descriptions reveal that enumeration of every allowed configuration does not occur. (A configuration is any consistent set of values of the system design parameters.) In most cases, less than one-tenth of all configurations need be considered.

In a network with two sizes of earth station, there are four ways in which they may be combined to form a one-way communications path or connection. With L representing the large station and S the small station, these connections are, L to L, L to S, S to L, and S to S. It was found expedient to design the program to consider two such connections on any single run -- either L-L and L-S or S-S and S-L. Total optimization is achieved in three or four successive runs. This program is known as the dual-station program (DSP).

In a run that considers L-L and L-S (S-S and S-L) connections, the large (small) station is said to be the host station and the small (large) station is said to be the auxiliary station. One of the input parameters to the DSP is the value of the receive G/T of the auxiliary stations. An accurate approximation of this value, for the first DSP run is obtained from a second program. It is known as the single-station program (SSP) and is identical to the DSP in all respects except that it optimizes a satellite communications system that permits only one size of earth station. The Satellite System Design Program is, therefore, a set of two programs that are used in tandem to calculate the optimum system design.

The following three subsections are intended to convey a basic understanding of program scope and structure. The first two indicate some of the major input and output parameters. The third gives a short explanation of program logic.

2. Input Parameters

Input parameters are variable constants, the value or values of which, for any particular program run, are determined externally and read in at the beginning of the run. Those of present interest fall into three groups: capacity, cost and cost-related parameters; demand parameters; and transmission parameters. They are described in the following section and listed together at its end in Table 2-1.

a) Capacity, cost and cost-related parameters

Each station is characterized by the three parameters that are subject to variation as the system is optimized. These are the antenna diameter, the equivalent input noise temperature of the antenna/receiver combination, and the saturated power rating of the power

Table 2-1

A Listing of Input Parameters for the Satellite System Design Program

---

⟨ Earth Station Equipment Parameters and Costs ⟩

1. 11 choices of antenna diameter
2. 8 choices of equivalent input noise temperature and corresponding pre-amplifier
3. 11 choices of saturated output power rating for the power amplifiers
4. cost figures for each of the above items include:
    a) initial capital cost
    b) assembly, integration, testing, management, handling, packaging, warranty and profit
    c) installation
    d) annual operations and maintenance

{ all are given as a percentage of initial capital cost

⟨ Satellite Equipment Parameters and Costs ⟩

1. 3 choices of satellite, that is of end-of-life rf power (saturated)
2. 1 choice of equivalent input noise temperature
3. 1 choice of antenna beamwidth
4. 1 choice of satellite lifetime
5. cost figures for each satellite are:
    a) in-orbit cost of initial satellite (including development)
    b) in-orbit cost of each additional satellite
    c) annual tracking, telemetry, and control cost

⟨ Demand Parameters ⟩

1. the length of the study period
2. the numbers of newly constructed earth stations that begin operation each year of the study period (large and small stations)
3. the four series of annual growth rates
4. the initial offered load, in erlangs, for each type of station in its first year of operation
5. the required satellite power, in watts, year by year for TV or other services sharing the satellite segment

(cont.)

Table 2-1 (cont.)

⟨ Transmission Parameters ⟩

1. the quality, in pWpO, of the four types of connection
2. the noise, in pWpO, contributed by sources other than up-link thermal, down-link thermal, and satellite intermodulation
3. the slant range from the satellite to the farthest earth station
4. the up-link and down-link frequencies
5. the up-link and down-link rain margins
6. the off-axis pointing angle from the satellite to the farthest earth station (including allowance for satellite station keeping and pointing accuracies)
7. the flux density limit (if any) for down-link transmissions
8. the threshold carrier-to-noise ratio on each of the four types of connection
9. the baseband processing improvement factor on each connection
10. the psophometric improvement factor on each connection

⟨ Control Parameters ⟩

these parameters select the various program options, initialize the search variables, and specify which, if any, earth-station or satellite equipment values are to be considered as fixed

⟨ Miscellaneous Parameters ⟩

these parameters include the required annual rate of return, the satellite launch failure rate, the values of the coefficients that are used in the approximation to the Erlang B formula, etc.

amplifier. The single item costs of available equipment for representative values of these "capacity" parameters were obtained from manufacturers. Together with their corresponding capacity parameters they are supplied at the beginning of each run. Thus, cost and capacity figures may be changed at any time to reflect more recent information. Since channelizing and terrestrial interface equipment are required for any system configuration, their cost is not included in the optimization. Land and building costs are estimated as a function of the square of the diameter of the earth-station antenna. The usual convention is followed of obtaining installation and operation and maintenance costs as a percentage of single item capital cost. The various percentages may be specified separately for each type of equipment and for each "capacity" within a given type.

The cost of the satellite segment, including development and launch, is based on the published figures in the domestic satellite filings before the FCC. However, as in all input data, these may be set at will as new cost information becomes available. Three satellites, representing the range of available rf power, are considered. Each is described to the program with five parameters: 1) total end-of-life rf power, 2) purchase and launch cost of the first satellite, including development, 3) purchase and launch cost of each additional satellite, 4) annual cost for station keeping and telemetry, command, and control, and 5) expected satellite lifetime.

It is assumed that any single satellite communications system will use a single type of satellite in order to avoid repeated payment of development costs. This assumption could be altered if satellites ever become a quasi "off-the-shelf" item.

b) Demand parameters

1) Regular option

Yearly changes in total demand for satellite circuits will, in general, be due both to system expansion from newly constructed earth stations and to natural demand growth at previously operating stations. These changes could be modeled in a variety of ways. The model in use at the present time is one that lends itself to rapid calculation yet is not too far removed from reality. The following is a sketch of the manner in which demand is presently handled. For a detailed explanation of demand generation see Appendix C.

The numbers of newly constructed large stations and of newly constructed small stations that begin service each year of the study are given as input parameters in separate input arrays. During its initial year of service, each newly constructed small earth station is offered a fixed traffic load for each of the two possible types of traffic connection -- a connection between itself and another small station or between itself and a large station. These initial loads are given as input parameters, since to a first approximation, they are not a function of the number of stations in operation. For newly constructed large stations only the initial load offered for connections with other large stations need be specified by the input.

Traffic increase from natural growth in demand at previously operating stations is determined using an annual percentage growth rate. However, instead of a constant rate being used during the entire study period, a different rate may be specified for each year. This allows the program to handle demand functions of virtually any form. In addition, it is recognized that the rates of growth on connections between large stations may differ altogether from those that pertain to connections between small stations, which, in turn, may differ from those that pertain to connections from small stations to large stations. Therefore, two separate input arrays specify the two series of annual growth rates that will be used during any single run of the DSP.

2. Overflow option

A second option exists for computing the natural growth component for large station-to-large station traffic. It is called the overflow option and is intended for use in situations where all future long-distance traffic among cities served by the large earth stations is to be carried by satellite. In any given program application the number of large stations, their location, and scheduled completion dates are assumed known. Each large station handles long-distance traffic for nearby communities, which, collectively, comprise the service area of the station. Before a station begins operation the traffic generated in its (future) service area will be handled by terrestrial circuits. Any traffic that is once handled by terrestrial circuits will remain on terrestrial circuits. After the station begins operation, all increases in the traffic with other large-station service areas will be handled by satellite circuits.

Input parameters for the overflow option have the same meaning as for the regular option with two exceptions. Before stating those exceptions, it is convenient to define the total demand for long-distance circuits that is generated in a large-station's service area, at the time the station begins operation as that station's or that area's base-line demand. To tie this definition to the explanation of the previous paragraph, an area's base-line demand is the demand that will remain on terrestrial circuits after the station serving that area begins operation. Increases in demand will be determined in reference to this base-line demand and it is these increases that will be offered to the large station for service on satellite circuits.

Individual station base-line demands are, however, ficticious entities with regards to program implementation since the program treats all large stations as though their offered loads were identical. A second definition will help in explaining how a station's base-line demand is actually determined. Let the average of all the large-station base-line demands (as given in the first definition), in the special case where all large stations begin operation in the first year of the study period, be defined as the initial average base-line demand. Now in the program the station base-line demand for all stations that begin service in the first year of the study period is taken to be the same as the initial average base-line demand. The station base-line demand for stations that begin service in any other year is obtained by adding specified year-to-year increases to the initial average base-line demand.

The first exception, then, is the parameter that in the regular option indicates the initial load, in erlangs, offered to newly constructed large stations for connections with other large stations. It is redefined as the initial average base-line demand. The second exception is the input array that in the regular option contains the year-to-year growth rates of the demand offered to a large station for circuits to other large stations. It is redefined to contain the year-to-year growth rates with which the average base-line demand (as a function of time) is obtained from the initial average base-line demand.

c) Transmission Parameters

The transmission parameters specify (for each of the four types of connection) the total allowed baseband noise, in picowatts of psophometrically weighted noise power at a point of zero transmission level (pWpO); the threshold value of carrier-to-noise ratio, in dB; the baseband signal processing improvement factor (e.g., pre-emphasis, compandering, speech clipping, etc.), in dB; the psophometric weighting improvement factor, in dB; and, the baseband noise contributed from all sources other than thermal and satellite intermodulation noise, in pWpO.

The satellite receiver noise temperature and the beamwidth of the satellite antennae are assumed known, and are also read in as input data.

3. Output Parameters

Of primary interest, of course, is the minimum-cost configuration. This is given in terms of the antenna diameters, the pre-amplifier noise temperatures, and the saturated power ratings of the sequences of power amplifiers at each station; the minimum-cost satellite; and, the required satellite launch stream. Of equal importance is the total cost of the system and various cost breakdowns such as the annual cost of an earth station and the annual cost of a satellite circuit. The output also contains the design values of baseband noise (prior to any up- or down-link attenuation) contributed by the up- and down-links and by transponder intermodulation distortion, the per-channel output power at the earth station and at the satellite, the year-by-year total satellite power requirement, the values of transponder back-off and the values of transponder gain.* A reproduction of the full formal output of the DSP is given in Appendix E.

4. Basic Program Logic and Block Diagrams

The program consists of two large segments of coding. The first, and smaller, segment accomplishes what shall be called preliminary calculations. Block diagrams of segment one are given in Figs. 2-1 and 2-2. The second segment is the main iterative routine where all feasible system configurations are evaluated in terms of overall cost. Figures 2-3 and 2-4 show block diagrams of segment two.

a) Preliminary calculations

One of the major requirements in terms of program complexity is that the minimum-cost system be calculated taking account of demand growth and system expansion over time. There are many ways to model growth and expansion. However, each is used solely to determine the number of earth stations, the number of channels per earth station, and the number of satellite channels required from year-to-year throughout the study period. These numbers must be known before total system cost may be calculated. Also, they need be calculated only once for each program run. For these reasons, maximum speed and flexibility is afforded by placing them in a subroutine as part of the preliminary calculations -- independent of the main iterative routine.

An important assumption affecting coding throughout the program is that all earth stations (in either one of the two size categories) will

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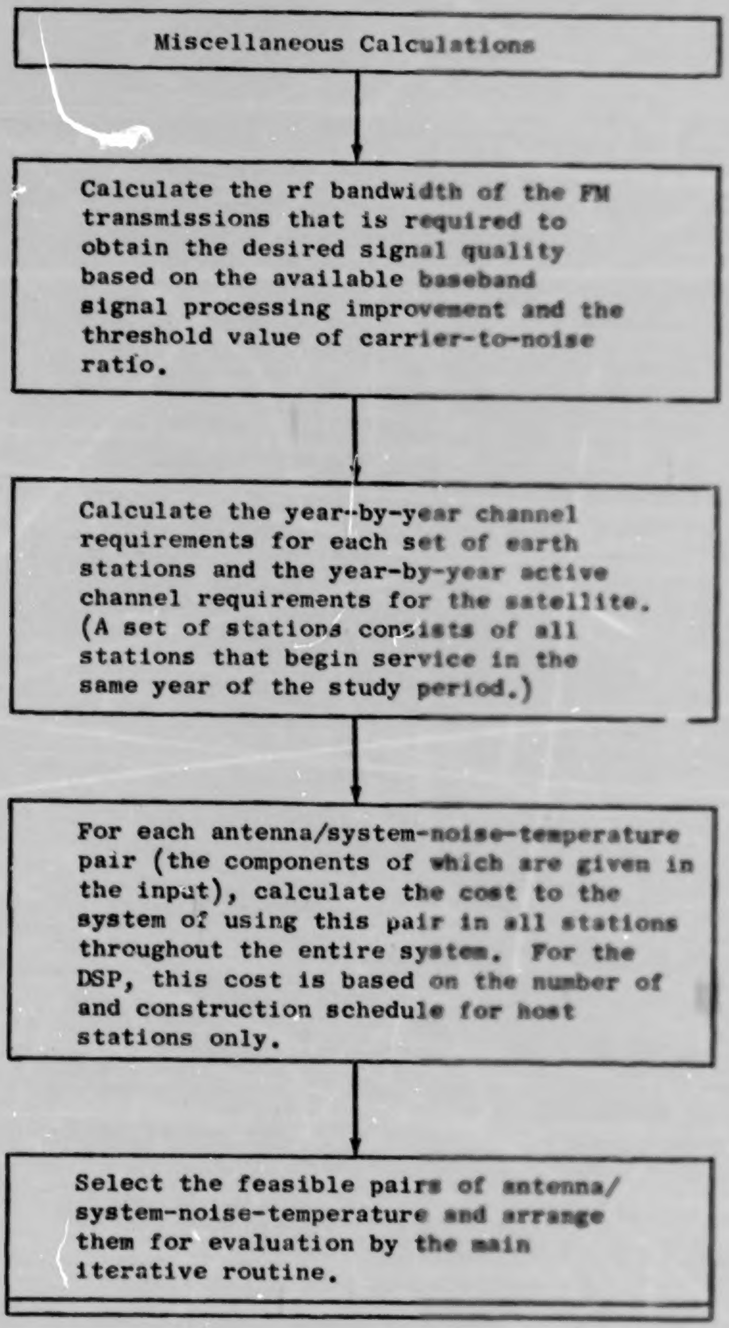
*For a discussion of one effect of transponder gain on system optimization, see Appendix D.



Miscellaneous Calculations

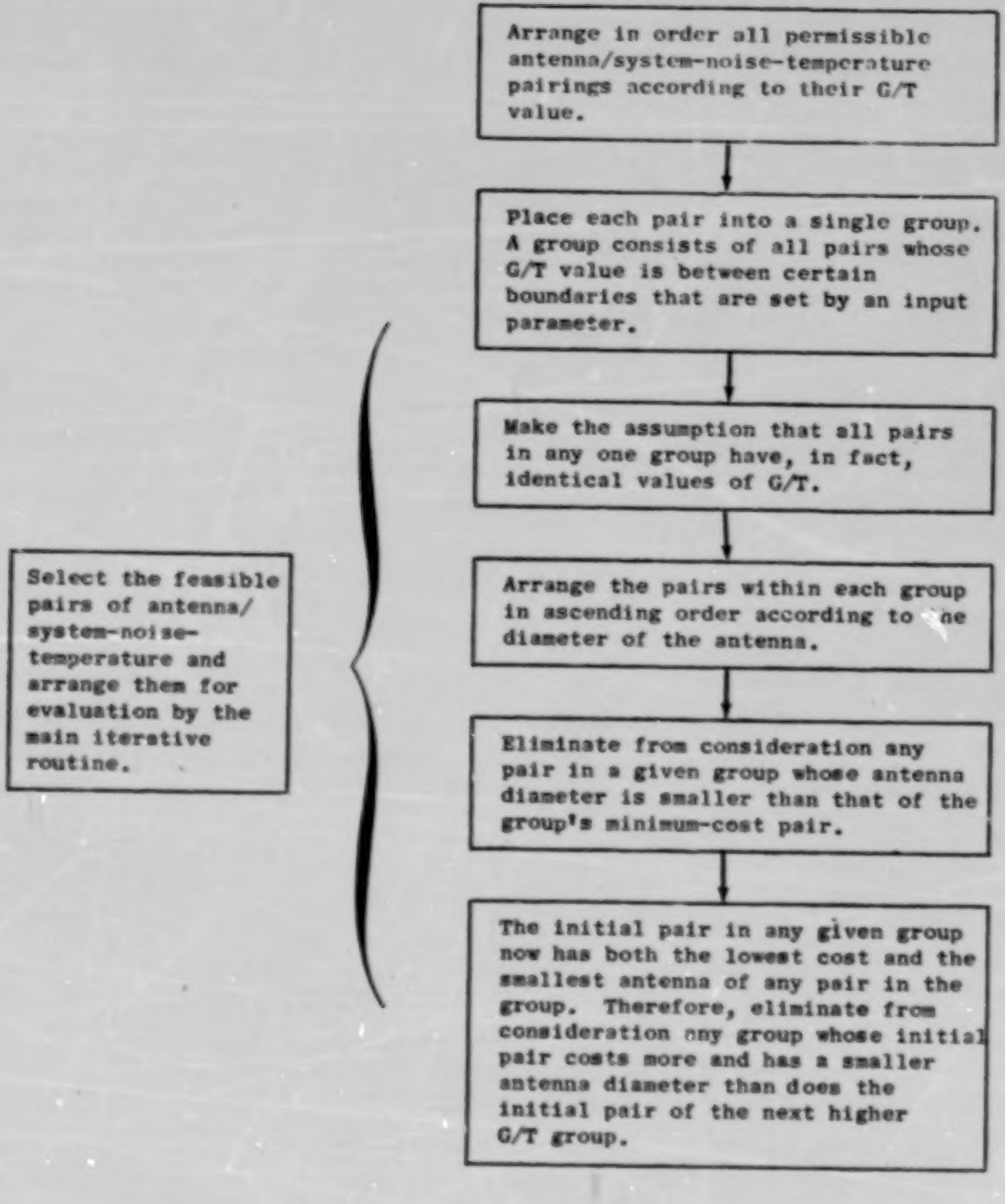
Calculate the rf bandwidth of the FM transmissions that is required to obtain the desired signal quality based on the available baseband signal processing improvement and the threshold value of carrier-to-noise ratio.

Calculate the year-by-year channel requirements for each set of earth stations and the year-by-year active channel requirements for the satellite. (A set of stations consists of all stations that begin service in the same year of the study period.)

For each antenna/system-noise-temperature pair (the components of which are given in the input), calculate the cost to the system of using this pair in all stations throughout the entire system. For the DSP, this cost is based on the number of and construction schedule for host stations only.

Select the feasible pairs of antenna/system-noise-temperature and arrange them for evaluation by the main iterative routine.

Fig. 2-1. A Functional Block Diagram of Segment One Coding



Arrange in order all permissible antenna/system-noise-temperature pairings according to their G/T value.

Place each pair into a single group. A group consists of all pairs whose G/T value is between certain boundaries that are set by an input parameter.

Make the assumption that all pairs in any one group have, in fact, identical values of G/T.

Arrange the pairs within each group in ascending order according to the diameter of the antenna.

Eliminate from consideration any pair in a given group whose antenna diameter is smaller than that of the group's minimum-cost pair.

The initial pair in any given group now has both the lowest cost and the smallest antenna of any pair in the group. Therefore, eliminate from consideration any group whose initial pair costs more and has a smaller antenna diameter than does the initial pair of the next higher G/T group.

Select the feasible pairs of antenna/system-noise-temperature and arrange them for evaluation by the main iterative routine.

Fig. 2-2. A Block Diagram of Feasible-Pair Selection in Segment One Coding

Loop 1

Select a trial value of $(G/T)_e$

Loop 2

Select a particular realization of the trial value of $(G/T)_e$ from the feasible pairs of antenna diameter/system noise temperature as determined in the Preliminary Calculations coding segment.

Loop 3

Select a trial value of satellite transponder output backoff, BO. (In the DSP this transponder type will handle circuits on host station-to-host station connections.)

Loop 4

Select a trial value of X, the ratio of the thermal noise contributed on the down-link to that contributed on the up-link. (In the DSP this value of X applies to circuits on host station-to-host station connections.)

Loops 5 and 6 occur only in the DSP

Loop 5

Select a trial value of satellite transponder output backoff, BOA, for transponders that handle half-circuits on host station-to-auxiliary station connections.

Loop 6

Select a trial value of XA, the ratio of the thermal noise contributed on the down-link to that contributed on the up-link on half-circuits on host station-to-auxiliary station connections.

Fig. 2-3. A Functional Block Diagram of the Loop Structure within the Main Iterative Routine

a. Calculate the trial noise budget(s) corresponding to the values of the four (six) loop variables.

b. Calculate the up-link carrier-to-noise ratio(s) and the down-link carrier-to-noise ratio(s) that are required to meet the trial noise budget(s). With these, calculate the up-link output power(s) and the down-link output power(s) per channel (not the eirp's).

c. Calculate the output backoff of the earth-station power amplifiers according to the allowed noise contribution from earth-station intermodulation distortion as specified in the input data and according to the number of carriers to be handled by the amplifier.

d. With the circuit demands as a function of time at each set of earth stations and at the satellite (from Preliminary Calculations) and using the results of steps b and c, calculate the required year-by-year power ratings of the earth-station power amplifiers for each set of earth stations -- that is, separate sequences of amplifier ratings must be calculated for stations that begin service in different years of the study period -- and the required year-by-year total rf power of the satellite.

e. Determine the least-cost type of satellite (from among the choices described by the input parameters) and the concomitant launch schedule to meet the year-by-year requirement on total rf power in the satellite.

f. Determine, for each set of earth stations, the cost (including repairs and partial replacements) of the sequence of power amplifiers required to meet the year-by-year requirement on total rf power in the satellite.

g. Add the cost of the satellite segment and the costs of the earth-station power amplifier sequences and the antenna/pre-amplifier pair (including land and building costs) to obtain total system cost.

h. Compare the total cost just obtained with that obtained during the preceding iteration to determine whether a bound has been reached and, if so, to which loop program control should it be transferred.

Fig. 2-4. A Sequence Listing of the Major Calculations Performed within Loop 4 (loop 6 of the DSP)

use identical antennas and pre-amplifiers. To accommodate more channels than its neighbor, an earth station will merely increase the power rating of its power amplifier. One consequence of this assumption is that the cost to the system of earth-station antennas and pre-amplifiers, given a particular earth-station construction schedule (specified in the input), may be calculated once, for each feasible combination of antenna and pre-amplifier, as part of the preliminary calculations and recalled from memory later on as needed.

The remaining significant block of coding in segment one selects from all possible combinations of earth-station antenna size and system noise temperature (as given by the input), those combinations that are feasible. Each feasible combination is placed into one of several groups, according to the value of the ratio of G/T. Within each group the feasible combinations are arranged in order of increasing antenna diameter, which is equivalent to an ordering by increasing cost. This ordering considerably reduces the time spent in the main routine, and may, therefore, be considered a permanent feature of the program.

In addition to the functions mentioned above, the Preliminary Calculations Segment also contains coding for miscellaneous items such as variable initiation, and for determining the required rf bandwidth of the FM transmissions. This is all indicated in Fig. 2-1.

The process of feasible pair selection, the last block in Fig. 2-1, is shown in more detail in Fig. 2-2. It can be explained as follows. To facilitate discussion, let the pair groups (where a pair group consists of all pairs whose G/T value is within a certain range, the boundaries of which are set by an input parameter) be indexed by IRC (which stands for index of the range center) and let the antenna diameter and system noise temperature of the minimum-cost pair of each pair group be designated as (AD^*_{IRC}, TE^*_{IRC}).

A non-feasible pair is any pair in a given pair group whose antenna diameter is smaller than AD^*_{IRC}. That such a pair would not be used in a minimum-cost system may be shown in three steps. First, by definition, the non-feasible pair would cost more, in and of itself, than (AD^*_{IRC}, TE^*_{IRC}). Second, to obtain the same value of G/T with an antenna that is smaller than AD^*_{IRC}, a non-feasible pair would have to have a receiver whose noise temperature is lower than TE_{IRC}. This translates into more required power per channel from the satellite than for (AD^*_{IRC}, TE^*_{IRC}). That is, for any fixed value of attenuation on the down-link a greater percentage degradation in effective receiver noise temperature will occur for the non-feasible pair as compared to the minimum-cost pair. This difference in potential link degradation will have to be offset by more power from the satellite to maintain the same margin requirement. And, third, with a smaller antenna, the power rating of the power amplifier associated with a non-feasible pair might have to be increased to preserve the same up-link eirp.

All three steps contain actual and potential cost differences that put the non-feasible pair at a disadvantage, which establishes the point.

b) Main iterative routine

1) Overall structure

The main iterative routine of the DSP is a nested loop structure with six levels, or loops (the SSP has four loops). The loop variables were chosen such that they, by themselves, are sufficient to uniquely specify a complete system configuration. The design parameters that comprise a system configuration are: the earth-station antenna diameters, receiver noise temperatures, and up-link eirp's per channel -- one eirp for each of the four types of connection (and from these the sequences of power amplifier ratings during the study period); the satellite receive G/T (given in the input), down-link eirp's, transponder output backoff's, and transponder gains (and from these the total satellite rf power requirement year-by-year, during the study period); and, the noise allocation among up-link, down-link, and satellite intermodulation noise on each of the four types of connection. Cost evaluation and comparison of feasible configurations is accomplished in a straight-forward manner through the natural action of the loop structure itself.

2) Design objective

Every system configuration that is evaluated meets all specifications given by the input parameters. (It makes no sense to evaluate systems that do not meet these specifications.) The quality of the telephone channels is specified with the input parameter QUAL. QUAL is the maximum, or worst-case, total baseband noise allowed per channel, in picowatts of psophometrically weighted noise power at a point of zero transmission level (pWpO). For the purpose of the Satellite System Design Program, the actual worst-case value of total baseband noise is expressed as the sum of the worst-case noise contributions from four sources, all given in pWpO: 1) NU", up-link thermal noise, 2) NI", noise due to intermodulation distortion in the satellite transponder, 3) ND", down-link thermal noise, and 4) NAO, noise from all sources other than the first three (NAO is given as an input parameter). Or,

$$QUAL \geq NU'' + NI'' + ND'' + NAO.$$

It is convenient to define NTH, the allowed worst-case thermal noise, as

$$\begin{aligned} NTH &= QUAL - NAO \\ &= NU'' + NI'' + ND'' \qquad (2.1) \end{aligned}$$

Although NI" is not thermal noise, it is so considered here because it has approximately the same effect on circuit quality. (11)

The design objective of the Satellite System Design Program, for which the major calculations are carried out in the main iterative routine, may be stated in reference to Eq. 2.1. The total cost of the system depends on the manner in which the total allowed baseband noise is allocated among the four noise sources in this equation. Therefore, the cost minimization problem is actually a noise allocation problem. The design objective is, then, to allocate the noise (or to determine the noise budget) such that the total cost of the necessary equipment and of its installation, operation and maintenance is a minimum.

3) Functional description

The following description is given in terms of the single station program (SSP). As stated earlier, the dual station program (DSP) is identical in most respects to the SSP except, of course, that it considers the use of two sizes of station instead of one. Differences in the programs will be indicated as appropriate.

Evaluation of feasible system configruations is accomplished in four steps (six in the DSP). Each step is contained in the correspondingly numbered loop of the nested loop structure, as shown in Fig. 2-3.

They are: 1) Select a trial value of the ratio of earth station antenna gain to equivalent system input noise temperature, $(G/T)_e$. The initial value should be smaller than the value that will be shown to be optimum since each new trial value on successive iterations is larger than its predecessor. 2) As each value of $(G/T)_e$ may be realized by one or more pairs of antenna diameter and equivalent system input noise temperature, the second step is to select one of the feasible pairs -- the least-cost combination being first -- for the particular value of $(G/T)_e$. 3) Select a trial value of satellite transponder output backoff. Again, and for the same reason given in conjunction with the choosing of an initial value of $(G/T)_e$, the initial value of backoff should be smaller than the optimum value. (In the DSP two initial values of transponder backoff are selected. One value applies for transmissions, or connections, among the host stations and one applies for connections from host stations to auxiliary stations.) 4) Select a trial value for X, the ratio of thermal noise contributed by the down-link to thermal noise contributed by the up-link (both contributions, of course, to be measured in pWpO at baseband in a telephone channel). (In the DSP, two trial values of this ratio are selected, corresponding to the two types of connection considered in each run.) With a value assigned to each of the loop parameters, the total system cost for one complete system configuration is calculated as an integral part of step four (step six of the DSP). Figure 2-4 lists the calculations that are involved and shows the sequence in which they are performed. (In the DSP the cost of the auxiliary stations and of the satellite segment associated therewith is obtained in a separate program run and included as part of the input data.) These calculations are explained further in what follows.

a. From Loop Variables to Total System Cost

The four (six in the DSP) parameters, or loop variables, may be shown to uniquely specify a single system configuration in the following manner. Let NU, NI, and ND be the design values of NU", NI", and ND", respectively. The design values, then, are those values that obtain when there is no rain loss in the transmission path. The rain losses, or link margins, are given as input parameters. The up-link margin is represented by MU, and the down-link margin by MD.

In single-channel-per-carrier systems using frequency modulation, the test tone-to-noise ratio is given by:

$$TT/N = \frac{3}{2} * (C/N) * (\frac{B_{rf}}{2\ f_m} - 1)^2 * (B_{rf}/f_m) * p * w$$

where TT/N is the test tone-to-noise ratio (a measure of the quality of the channel),

C/N is the received carrier-to-noise ratio,

B_{rf} is the rf bandwidth of the channel,

f_m is the maximum baseband frequency,

p is the baseband processing improvement factor, and

w is the psophometric weighting improvement factor.

In a given application, B_{rf}, f_m, p, and w are fixed. Therefore,

$$TT/N = K' * (C/N) \tag{2.2}$$

where $K' = (3/2) * ((B_{rf}/2f_m) - 1)^2 * (B_{rf}/f_m) * p * w$, and may be treated as a constant. TT/N and actual total baseband noise in a telephone channel, represented by $(pWpO)_{bb}$, are alternative ways to describe channel quality. Each may be expressed in terms of the other. The equation relating them is, (16)

$$10 * \log(TT/N) = 90 - 10*\log(pWpO)_{bb}$$

or,

$$TT/N = 10^9/(pWpO)_{bb} \qquad (2.3)$$

Substituting Eq. 2.3 into 2.2, and solving for $(pWpO)_{bb}$,

$$(pWpO)_{bb} = 10^9/(K'*(C/N))$$

or,

$$(pWpO)_{bb} = K/(C/N) \qquad (2.4)$$

where $K = 10^9/K'$.

Thus, the total baseband noise in the telephone channel is inversely proportional to the received carrier-to-noise ratio, as long as the carrier-to-noise ratio is above threshold. This establishes the following relationships:

$$NU'' = MU*NU, \qquad (2.5)$$

$$NI'' = MU*NI, \qquad (2.6)$$

$$ND'' = NU*ND', \qquad (2.7)$$

where ND' is the down-link noise obtained when rain loss occurs only in the down link.

To determine the relation between ND' and ND, it is useful to recall that the equivalent output temperature, T_{ao}, of an attenuator whose physical temperature is T is given by, (17)

$$T_{ao} = T\cdot(1 - g),$$

where 1/g is the loss of the attenuator, or g is the attenuator "gain." The attenuator in this case is the rain whose physical temperature is approximately equal to T_o (=290 ^{o}K), and whose "gain" is 1/MD. The actual equivalent input noise temperature at the earth station, $T_{e,actual}$, is the sum of the noise temperature before degradation due to rain loss, T_e, plus the equivalent output temperature of the rain loss attenuator, T_{ao}. Or,

$$T_{e,actual} = T_e + T_{ao}.$$

From the above disucssion, we may write,

$$(C/N)_{d,\text{ without attenuation on the down-link}} = (K/ND) = \frac{C}{k\cdot T_e\cdot B_{rf}} \qquad (2.8)$$

and

$$(C/N)_{d,\text{ with attenuation on the down-link}} = (K/ND') = \frac{C/MD}{k\cdot(T_e+T_{ao})\cdot B_{rf}} \qquad (2.9)$$

where k is Boltzman's constant. Other variables are as previously defined. Taking the ratio of Eq. 2.8 to 2.9,

$$\frac{ND'}{ND} = \frac{MD*(T_e+T_{ao})}{T_e}$$

or

$$ND' = MD*(1 + (T_o/T_e)\ (1 - 1/MD))*ND. \qquad (2.10)$$

Substituting Eq. 2.10 into 2.7,

$$ND'' = MU*MD*(1 + (T_o/T_e)*(1 - 1/MD))*ND. \qquad (2.11)$$

Substituting Eqs. 2.5, 2.6, and 2.11 into 2.1,

$$NTH = MU*(NU + NI + MD*(1 + (T_o/T_e)\ (1 - 1/MD))*ND.$$

Since X is defined as ND/NU, NU may be written as,

$$NU = (NTH/MU - NI)/(1 + X*MD*(1 + (T_o/T_e)*(1 - 1/MD))).$$

In this expression for NU, NI is the only unknown. (Remember that NTH may be calculated from input parameters and that T_e and X are selected in steps two and four, respectively, as the evaluation of the various feasible system configurations proceeds.) NI is, in general, a function of the number of carriers that simultaneously access the satellite transponder and of the transponder output backoff. However, it has been shown that, as in the present case, if the number of carriers accessing the transponder is greater than approximately 16, NI is a function of transponder output backoff only. (18)

Step three, above, assigns trial values of transponder output backoff. Thus, each iteration of steps one through four, or any subset thereof, is equivalent to selecting a new trial noise budget since these four steps determine NI, NU, and ND. $(C/N)_u$ and $(C/N)_d$ are now easily determined using Eq. 2.4, and with these the up-link power (the up-link eirp divided by the transmit gain of the earth-station antenna) and the down-link power (the satellite eirp per channel divided by the gain of the satellite antenna) can be calculated. In short, all cost-related parameters of the system configuration that corresponds to a trial noise budget are now known or can be calculated.

The values of the parameters of the minimum-cost configuration are retained and printed in the format shown in Appendix E. The values of a few key parameters associated with the minimum-cost noise budget for each of the trial values of earth-station $(G/T)_e$ (step one) are also retained. They are printed as shown on page 13 of Appendix E.

b. The Total Cost Curve vs The Loop Variables

As already mentioned, the program generates trial configurations by iteration over the four steps, or program loops, outlined at the first of this section. For a given combination of earth-station antenna diameter and equivalent input noise temperature, the various ways in which the total noise may be allocated are obtained by repeating step four a number of times for each repetition of step three. The number of times that step four is repeated before repeating step three depends on the value of total system cost after each step-four iteration. In general, as X, the loop variable in step four (defined as the ratio of down-link thermal noise to up-link thermal noise), increases while keeping the other three loop variables constant, the cost of the earth-station power amplifier tends to increase and the cost of the satellite segment tends to decrease. Although monotonic, these variations in cost exhibit a "staircase" appearance when plotted vs X. Therefore, although the curve representing the sum of these two costs will exhibit a minimum, it may not be monotonic on either side of the minimum. For each value of the loop variable in step three, a step four will be repeated until two successive repetitions both yield a total cost increase.

This same behavior of total cost is shown when all loop variables are held constant except the loop three variable. This variable, BO, is the output backoff of the satellite transponder. As BO increases (all other loop variables remaining fixed), the cost of the earth-station power amplifier tends to decrease. The cost of the satellite segment will first decrease (if the initial value of BO is sufficiently low) and then increase. This occurs because the cost of the satellite segment depends on total power required and not just on the useful output power. As BO is increased, less noise is contributed by intermodulation distortion in the transponder so more noise may be allocated to the up-link and to the down-link. More down-link noise means lower down-link output power. However, total satellite power is the product of output power and transponder output backoff. It is this quantity that first decreases to a minimum and then increases.

Figure 2-5 shows the behavior just described. It is a plot of X vs total system cost, with BO as a parameter, from an actual run of the single station program. For this figure, the diameter of the earth-station antenna is 15' and the equivalent input noise temperature of the station is 385 °K.

Figure 2-6 reveals, as expected, that total system cost also exhibits a minimum when X and BO are held constant and distinct trial configurations are obtained by changing $(G/T)_e$ (and the combination of G and T for any particular value of $(G/T)_e$ only). In this figure, BO is equal to 6 dB and X is equal to a ratio of 4.

E. PROGRAM RUNS FOR A TYPICAL DEMAND SITUATION

1. Values of the Demand Parameters

The traffic data for the program runs reported on in this section were derived from 1971 Canadian national long-distance aggregate telephone statistics and from the 1970 Canadian Census. The average per-capita offered load, in erlangs, for long distance calls was approximated and used to estimate the long-distance traffic load that would be offered by each town, city, or metropolitan area. Three different levels of aggregate demand for satellite circuits were developed, representing a lower bound level, a nominal level, and an upper bound level. (See Appendix F for details.) In Table 2-2 these levels are described in terms of the demand parameters that were mentioned earlier and that are more fully explained in Appendix C.

The figures presented in the output format in Appendix E are the results of program runs using the nominal demand level. This section

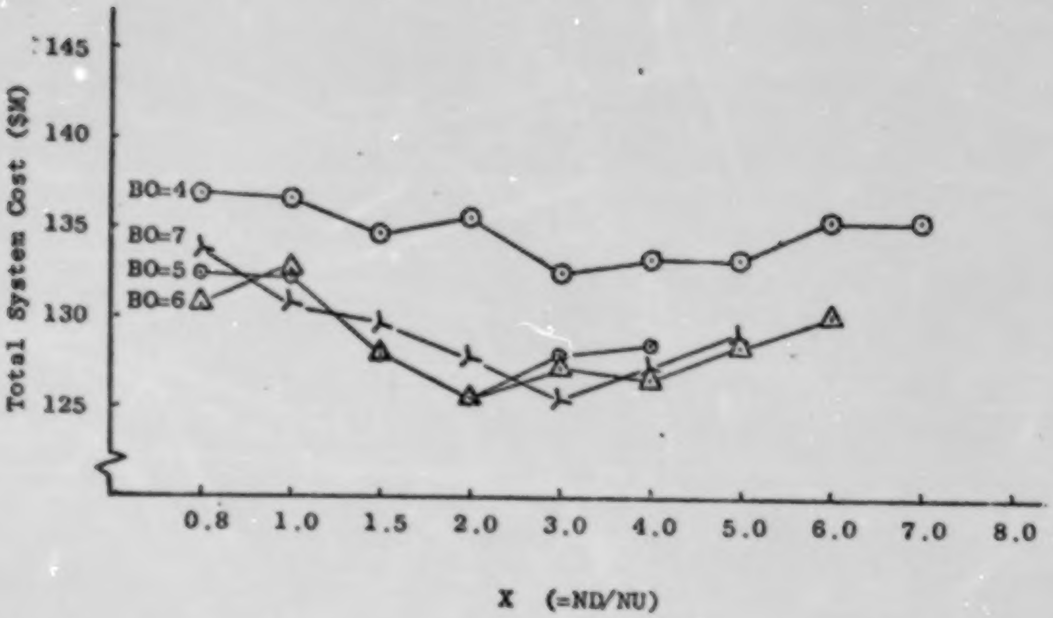


Fig. 2-5. Total System Cost vs X, with BO as a Parameter. (X is the Ratio of Down-link Noise to Up-link Noise. BO is the Satellite Transponder Output Backoff, in dB.) (SSP run, nominal demand)

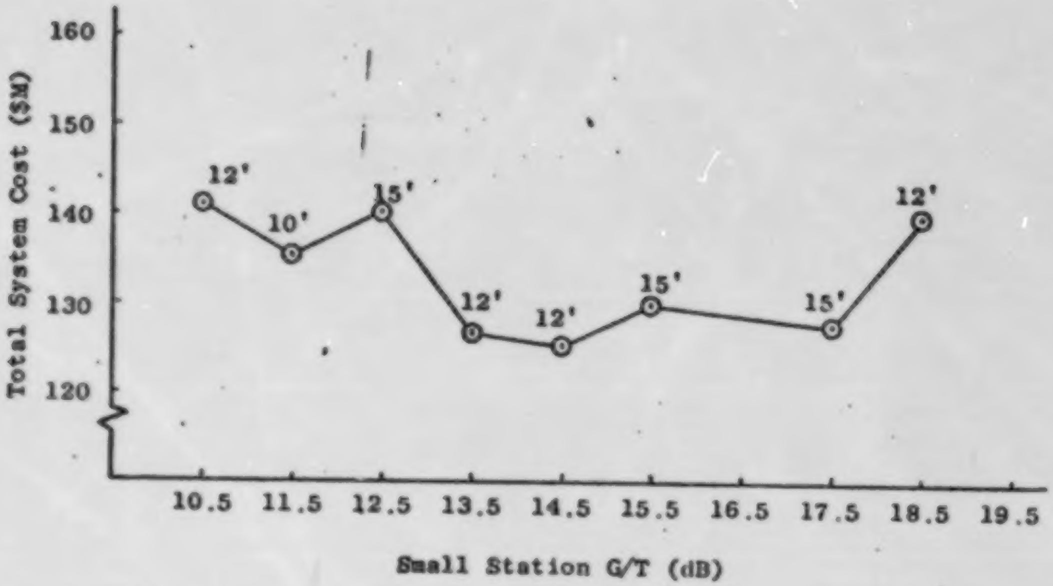


Fig. 2-6. Total System Cost vs Small Station G/T, with Small Station Antenna Diameter as a Parameter. (SSP run, nominal demand)

Table 2-2

Assumed Demand Level for a Canadian Domestic Satellite System

Demand Parameter	Demand Level		
	Lower	Nominal	Upper
Demand Option	regular	regular	overflow
E_{oss}, in erlangs*	0.125	0.125	0.330
E_{osl}, in erlangs*	0.275	0.275	0.720
E_{oll}, in erlangs	40.0	40.0	600.0
NS(1),...,NS(5)	100	200	300
NS(6),...,NS(15)	0	0	0
NL(1),...,NL(5)	2	2	2
NL(2),...,NL(5)	0	2	2
NL(6),...,NL(15)	0	0	0
RSS(1),...,RSS(15)	12%	12%	12%
RSL(1),...,RSL(15)	12%	12%	12%
RLL(1),...,RLL(15)	12%	12%	12%

*For a P.01 grade of service in obtaining a non-busy transmitter-receiver pair at an earth station, an offered load of 0.4 erlangs (= 0.125 + 0.275) requires three transmitter-receiver (T-R) pairs. Growing at the constant rate of 12% per year, an initial load of 0.4 erlangs will become a 15-year load of 2.18 erlangs, requiring seven T-R pairs.

Definitions for Table 2-2

E_{oss}, E_{osl}	are the loads, in erlangs, offered to a small station during its initial year of service for circuits to all other small stations and to large stations, respectively.
E_{oll}	is the load, in erlangs, offered to a large station during its initial year of service for circuits to all other large stations. In the overflow option it is the initial average base-line demand, as defined in the text.
NS(·), NL(·)	are the number of small stations and the number of large stations, respectively, that begin service in year (·) of the study period.

(cont)

Table 2-2 (cont)

$RSS(\cdot)$, $RSL(\cdot)$ are the percentage increases in load offered to a small station during year $(\cdot)$ of the study period for circuits to all other small stations and to large stations, respectively.

$RLL(\cdot)$ is the percentage increase in load offered to a large station during year $(\cdot)$ of the study period for circuits with all other large stations.

will not give the results for each demand level in such detail. Instead, a summary of the optimum configuration for each level shall be given together with examples of the cost of using non-optimum values of transponder gain and small station (G/T).

2. Other Input Parameter Values

For each level of demand: the length of the study period is equal to 15 years; an overall grade of service of P.03 (19) is assumed to be equally divided among origination station, satellite, and termination station; the quality of all large station-to-large station circuits corresponds to 10,000 pWpO of baseband noise, worse-case, or to a weighted test tone-to-noise ratio of 50 dB; circuits handled by small stations are allowed 100,000 pWpO, worse-case, or a 40 dB weighted test tone-to-noise ratio; the threshold carrier-to-noise ratio ($(C/N)_{threshold}$) is 10 dB and the baseband processing improvement factor is 4 dB for all four types of connection; a constant load of 36 w of satellite power is reserved for two channels of national television; the satellite antenna beamwidth is set at 5 by 7 degrees; and, the equivalent input noise temperature of the satellite is 1200 °K.

3. Description of the Lower Bound Level of Demand

It may prove helpful to give a word description of the lower bound level. Two large stations provide a large cross-section route between Vancouver, B.C. and Ottawa, Ontario and act as access points to the already existing terrestrial network within their respective service areas for communities served only by satellite. These two stations will begin operation when the initial satellite is launched. (In general, the number of newly constructed large stations that begin operation each year of the study period of represented by NL(T)).

A total of 500 small stations handle the long-distance traffic of small- to intermediate-sized communities. One hundred of them will be installed to begin operation with the initial satellite launch. An additional 100 stations will begin operation at the first of each succeeding year of the study up to the fifth year. No further small station construction is anticipated. (In general, the number of newly constructed small stations that begin operation each year of the study period are represented by NS(T).)

The initial load offered to each small station is 0.40 erlangs, of which 0.125 erlangs (E_{css}) is for connections to other small stations and 0.275 (E_{osl}) is for connections to the large stations. From these initial loads, the traffic carried by each small station will increase at 12% per year, as shown by DS(T). DS(T) is the percent increase in demand offered to small stations from year T to year T + 1. An initial load of 40 erlangs (E_{oll}) is carried over circuits between the two large stations. The large station-to-large station traffic will also grow at 12% per year, as shown by DL(T). DL(T) is the percent increase in demand offered to large stations for circuits with other large stations from year T to year T + 1.

4. The Optimum System Design

Table 2-3 shows, for each demand level, certain key parameters of the optimum system configuration. (Each configuration was determined without the advantage of some 3 dB in carrier-to-intermodulation noise ratio that has been shown to exist for single-channel-per-carrier

Table 2-3

Key Parameter Values for the Optimum (Least-Cost) System Configuration for the Three Demand Levels Assumed for Canada (D_e's, T_e's, and $P_{e,i}$'s are Earth Station Antenna Diameters, in Feet, Earth Station Equivalent Input System Noise Temperatures, in Degrees Kelvin, and Power Ratings of the Initial Earth Station Power Amplifiers, in Watts, Respectively.)

Demand Level	Total Cost ($M)	Small St'n Parameters			Large St'n Parameters			Transponder Gains(dB)	
		D_e	T_e	$P_{e,i}$	D_e	T_e	$P_{e,i}$	L-L	S-S
Lower	89.1 54.8	12	400	20	25	100	1000	108	123
Nominal	116.2 83.2	15	350	10	32	100	300	109	123
Upper	170.5 150.5	15	350	20	32	60	1000	107	121

To get transponder gain in $dB/dB/m^2$ add 12.8 dB to G_{tr} or $GT = G_{tr} + G_s + G_s - 37$

where G_s = gain at 3.5 dB down.

operation. (20) Furthermore, it is assumed that fully variable demand access is not implemented, being too costly in terms of earth-station channelization and signaling equipment. This assumption increases by a factor of 1.15 the number of active satellite channels above the number required for fully variable operation. And, finally, link calculations are made assuming that all earth stations are located at the 3 dB beam edge of the satellite antenna beamwidth. These leanings in favor of conservative system design will be partially, though not totally, offset by the various system losses that are not explicitly shown, such as line losses at the earth stations.)

5. Cost Sensitivity to Small Station G/T

From the program print-out of the minimum-cost configuration corresponding to each trial combination of earth-station G/T one may show the penalty that would be incurred if, for example, a non-optimum value of G/T were selected for the small station. Figures 2-7, 2-8, and 2-9 are curves of total system cost, for each demand level, as a function of small station G/T. The large station parameters, in each case, were held constant.

As expected, the total cost of the system exhibits a fairly flat minimum with respect to small station G/T. In addition, the minimum is fairly broad. For example, in the cases shown, the total cost has increased by less than 10% for G/T values 2 dB away from the optimum value. Obviously, the percentage increase at 2 dB decreases as the number of small stations decreases.

It may be seen, however, that there is a significant cost increase when a 20 ft. antenna is chosen for the small stations. This is due

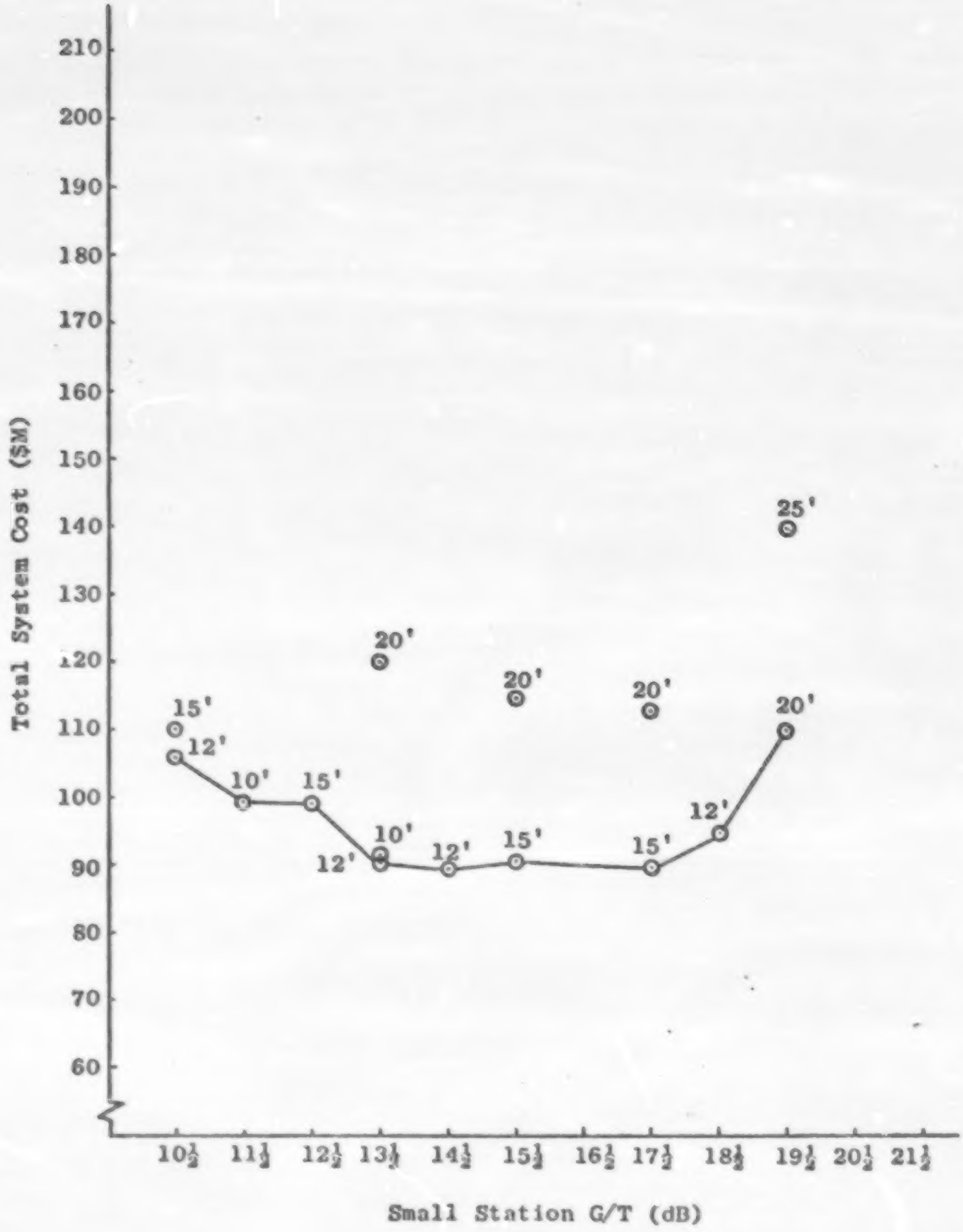


Fig. 2-7. Total System Cost versus Small Station G/T, with Small Station Antenna Diameter as a Parameter. (DSP run, lower demand)

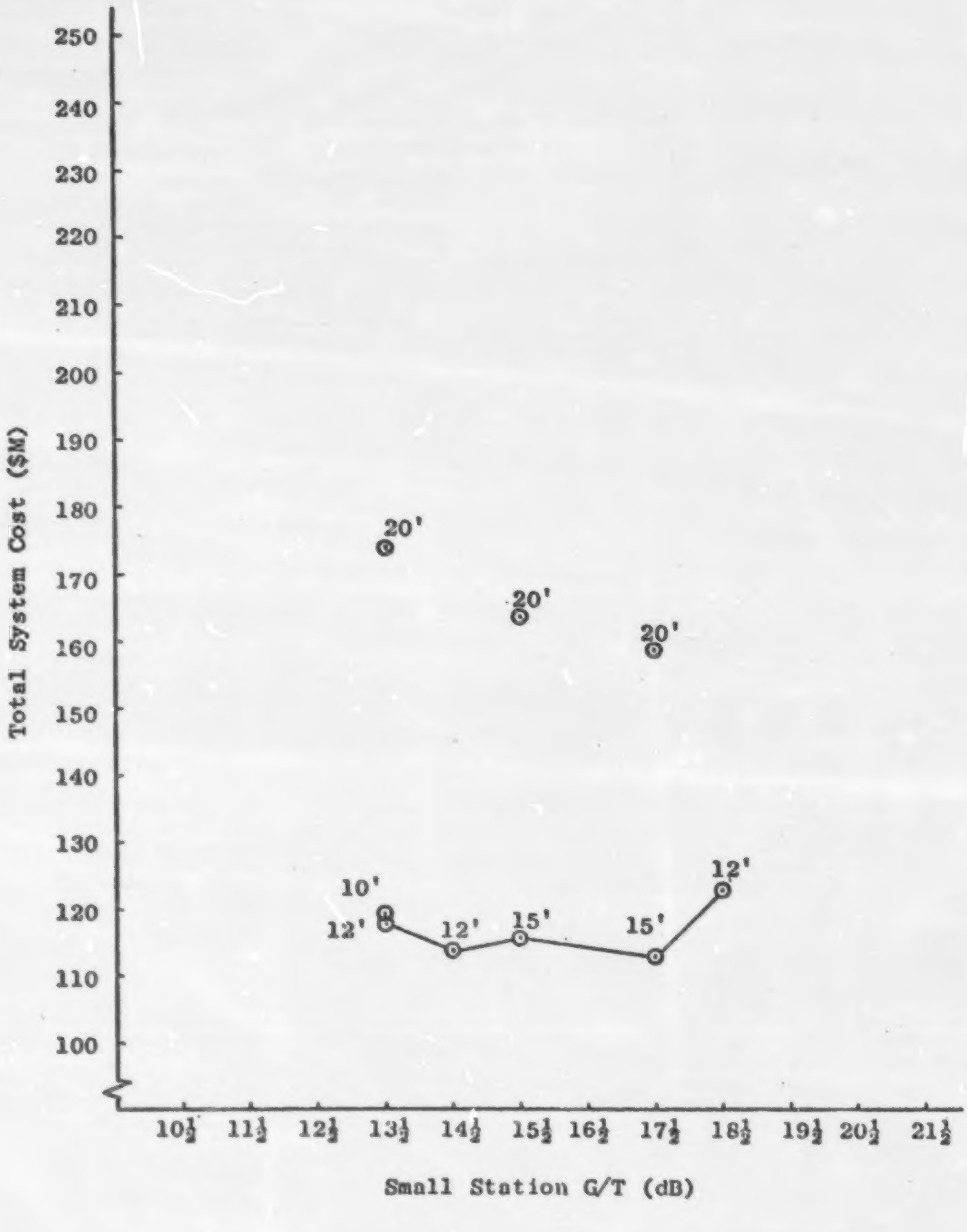


Fig. 2-8. Total System Cost versus Small Station G/T, with Small Station Antenna Diameter as a Parameter. (DSP run, nominal demand)

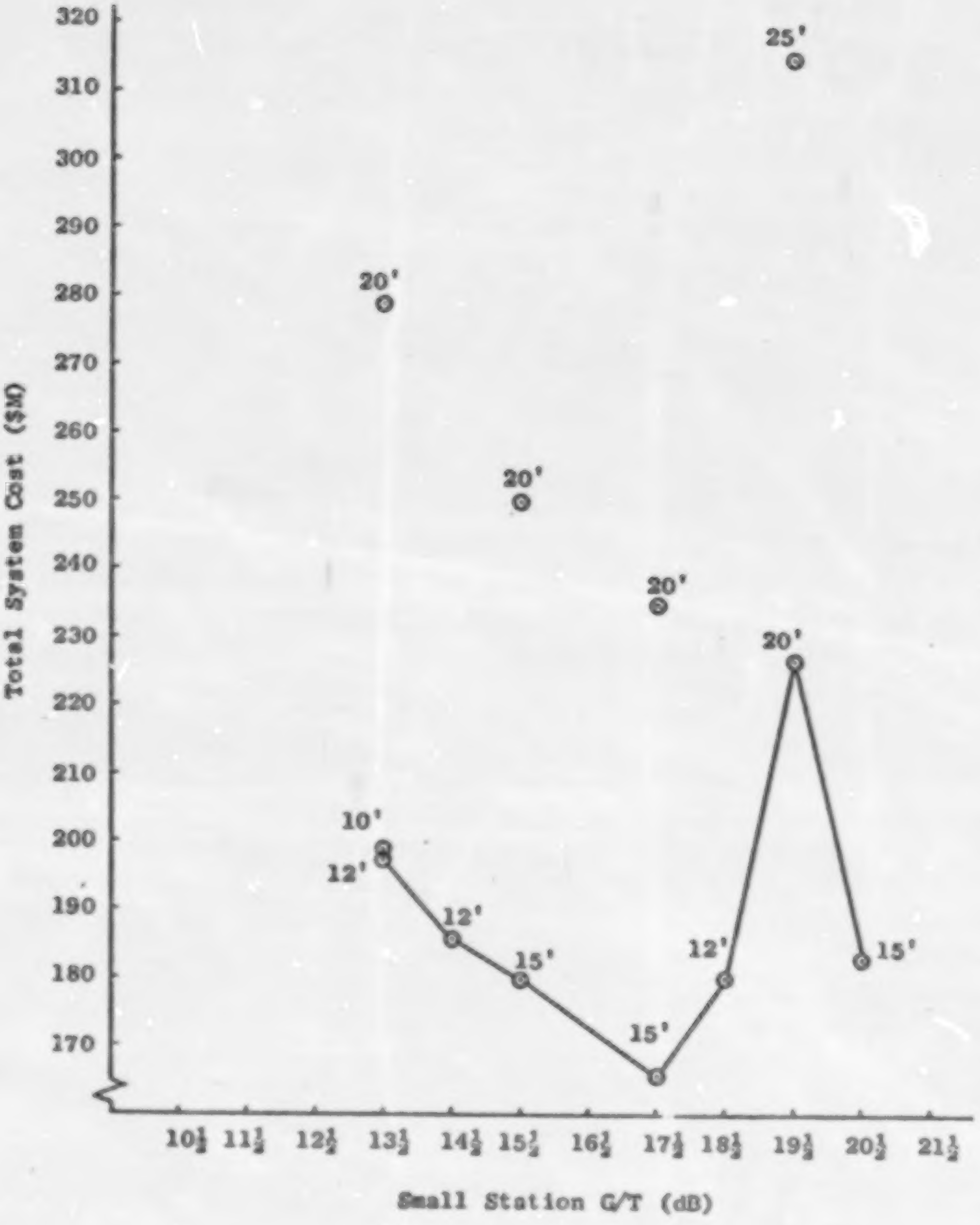


Fig. 2-9. Total System Cost versus Small Station G/T, with Small Station Antenna Diameter as a Parameter. (DSP run, upper demand)

almost entirely, to the cost difference between the 15 ft. ($7,000) and the 20 ft. ($32,000) antennae. (Notice that the penalty, as a percentage of the optimum value of total cost, increases as the number of small stations increases.) Naturally, if this difference were reduced, there would come a point at which the 20 ft. antenna would be the optimum choice. It would be possible to determine the dollar value of the difference at the cross-over point using the program. As yet, we have not done so.

6. Cost Sensitivity to Satellite Transponder Gain

To illustrate the merit of choosing the proper values for the transponder gains, Table 2-4 compares the unconstrained optimum configurations with the least-cost configurations given that the transponder gains are fixed and set equal to the gain that obtains for large station-to-large station connections in the unconstrained optimum configurations. The cost differences although small, relatively speaking, are not negligible. Nevertheless, it should be remembered that for all three demand levels, the optimum large-station antenna diameter is much smaller than those of the present "standard" stations of the Intelsat system. Thus, the optimum transponder gain for large station-to-large station traffic is larger and the difference between this gain and the optimum gain for small station-to-small station connections is smaller than would be the case for large stations conforming to Intelsat standards. As shown in Appendix D, the larger the difference between the optimum transponder gains, the greater the cost penalty associated with the use of the large station-to-large station gain for small station-to-small station connections.

Table 2-4

Key Parameter Values for the Optimum (Least-Cost) System Configuration for the Three Demand Levels Assumed for Canada Compared to the Values of these Parameters When the Satellite Transponder Gains are Fixed and Set Equal to the Gain that Obtains in the Optimum System for Connections Between Large Stations

Demand Level	Total Cost($M)	Small St'n Parameters			Large St'n Parameters			Transponder Gains(dB)	
		D_e	T_e	$P_{e,i}$	D_e	T_e	$P_{e,i}$	L-L	S-S
Lower Opt.	89.1 54.8	12	400	20	25	100	1000	108	123
Forced	96.3 51.7	15	350	100	25	100	1000	108	108
Nominal Opt.	116.2 83.2	15	350	10	32	100	300	109	123
Forced	127.9 92.2	15	350	100	25	100	1000	109	109
Upper Opt.	170.5 150.5	15	350	20	32	60	1000	107	121
Forced	201.6 179.4	15	350	300	32	60	3000	107	107

7. Cost Sensitivity to Baseband Signal Processing

Using the Satellite System Design Program one may easily inquire whether by using more sophisticated baseband signal processing the cost of the system could be reduced. The trade-off is an increased cost for the processing equipment vs a reduced cost for transmission -- because of narrower bandwidths and lower threshold carrier-to-noise ratios. Table 2-5 shows the results of a run using the nominal demand level where the threshold was reduced to 7.5 dB and the improvement due to baseband signal processing was increased from 4.0 dB (pre-emphasis only) to 15.3 dB (a combination of pre-emphasis, compandoring and "click" suppression). The difference in total cost corresponds to a difference of $600 per channel per year for every earth-station channel in the system. From this, it would appear that up to approximately $3000 per channel in initial capital costs may be incurred before baseband processing is no longer the least-cost alternative.

An even more favorable position for baseband processing obtains when it is assumed that the revenue to pay for the satellite segment cost of providing 36 w for network television is not obtained from charges for the use of telephony channels. In the nominal demand level, the satellite power for television is approximately 40% of the total present number of watt-years of required power. When this fraction of the satellite segment cost is subtracted from the total system cost, an initial cost difference of about $4000 per channel may be justified for baseband processing.

Table 2-5

Key Parameter Values for the Optimum (Least-Cost) System Configuration for the Nominal Demand Level Assumed for Canada (Case One is for $(C/N)_{\text{threshold}} = 10$ dB and Baseband Processing Improvement = 4 dB. Case Two is for $(C/N)_{\text{threshold}} = 7.5$ dB and Baseband Processing Improvement = 15.3 dB.)

Case	Total Cost($M)	Small St'n Parameters			Large St'n Parameters			Transponder Gains(dB)	
		D_e	T_e	$P_{e,i}$	D_e	T_e	$P_{e,i}$	L-L	S-S
One	116.2	15	350	10	32	100	300	109	123
Two	91.8	10	350	5	20	100	100	115	124

F. THE SATELLITE FACILITY MATRIX

Anticipating the need to economically integrate the satellite facility with existing and planned terrestrial facilities (a comprehensive method of network planning is given in Chapter IV), it is convenient at this point to present satellite facility costs and optimum parameter values for several possible combinations of the required number of network earth stations and the average offered load, in erlangs, per station. They are presented in Table 2-6 which shall be referred to henceforth as the Satellite Facility Matrix. All matrix entries were obtained using the Single Station Program* with identical values of all of the input parameters except those that represent the number of earth stations and the average offered load per station. The common values of the relevant input parameters are given in Table 2-7. The values of the total end-of-period (15 years) number of network stations and of the total end-of-period demand that is served by the satellite are indicated on the matrix.

For each different combination of the values of these two input parameters (the average demand, or load, per station is the actual input parameter), the corresponding minimum-cost values of earth-station antenna diameter (D_a) and system noise temperature (T_s), total annual cost per circuit (A$/C), and satellite transponder gain (G_{tr}) are shown.

---

*It is quite likely that one of the options that will be available to individual nations that are considering the establishment of a national satellite system is that of leasing space-segment capacity on an existing satellite . A lease option, characterized by an annual lease fee per transponder or per watt, may be specified with either of the Satellite System Design Programs. The Satellite Facility Matrix is based on this lease option using an annual cost per watt of $100,000.

Table 2-6

SATELLITE FACILITY MATRIX

Total End-of-Period Demand Served by Satellite (in erlangs)

TOTAL END-OF-PERIOD NUMBER OF STATIONS		40	80	200	400	2000	4000	[illegible]
10	D_s	15'	15'	20'	25'	32'	32'	[illegible]
	T_s	75°	75°	75°	75°	90°	90°	90°
	A$/C	$5170	$3464	$2432	$1714	$710	$512	$410
	G_{tr}	114.5dB	111.5dB	109.5dB	103.7dB	105.5dB	103.7dB	103.0dB
	erl	1.9	3.6	9.0	19.0	90.0	180.0	360.0
	ch	7-19	10-30	19-64	31-116	119-519	223-1010	[illegible]
20	D_s	15'	15'	15'	20'	25'	32'	32'
	T_s	115°	75°	75°	75°	75°	90°	90°
	A$/C	$5000	$4059	$2922	$2004	$960	$656	$396
	G_{tr}	114.7dB	114.5dB	111.5dB	110.7dB	107.5dB	103.7dB	104.5dB
	erl	0.0	1.9	4.5	9.0	45.0	90.0	180.0
	ch	5-11	7-19	11-36	19-64	65-269	119-519	223-1010
50	D_s	15'	15'	15'	15'	25'	25'	32'
	T_s	115°	115°	115°	75°	75°	75°	90°
	A$/C	$4946	$4222	$3232	$2640	$1344	$979	$699
	G_{tr}	114.7dB	114.7dB	113.5dB	111.5dB	107.5dB	107.5dB	105.5dB
	erl	0.36	0.72	1.9	3.6	19.0	36.0	72.0
	ch	3-7	4-10	7-19	10-30	31-116	54-219	97-419
100	D_s	15'	15'	15'	15'	20'	20'	25'
	T_s	360°	180°	115°	115°	75°	75°	75°
	A$/C	$4710	$4278	$3462	$2970	$1704	$1250	$930
	G_{tr}	119.5dB	116.7dB	113.5dB	114.7dB	110.7dB	108.5dB	105.5dB
	erl	0.19	0.36	0.90	1.80	9.0	19.0	36.0
	ch	3-5	3-7	5-11	7-19	19-64	31-116	54-219
500	D_s	12'	12'	15'	15'	15'	15'	20'
	T_s	360°	360°	360°	180°	115°	75°	75°
	A$/C	$3956	$3890	$3526	$3466	$2492	$2134	$1702
	G_{tr}	120.5dB	120.5dB	119.5dB	116.7dB	114.7dB	111.5dB	110.7dB
	erl	0.045	0.072	0.19	0.36	1.9	3.6	7.2
	ch	2-3	2-3	3-5	3-7	7-19	10-30	15-53
1000	D_s	12'		12'	15'	15'	15'	15'
	T_s	360°		360°	360°	115°	115°	75°
	A$/C	$3310		$3529	$3232	$2792	$2390	$2100
	G_{tr}	120.5dB		120.5dB	119.5dB	114.7dB	114.7dB	114.5dB
	erl	0.019		0.09	0.19	0.9	1.9	3.6
	ch	2-2		2-4	3-5	5-11	7-19	10-30
2000	D_s	10'	12'	12'	12'	15'	15'	15'
	T_s	500°	360°	360°	360°	180°	115°	115°
	A$/C	$2900	$3104	$3294	$3252	$2980	$2696	$2314
	G_{tr}	124.7dB	120.5dB	120.5dB	120.5dB	116.7dB	114.7dB	114.7dB
	erl	0.009	0.019	0.045	0.09	0.45	0.9	1.9
	ch	2-2	2-2	2-3	2-4	4-7	5-11	7-19

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Table 2-7

The Values of Some of the Input Parameters that were Held Constant During the Program Runs that Generated the Data Shown in the Satellite Facility Matrix

Input Parameter	Value
Total allowed baseband noise, per channel	10,000 pWpO
Noise contributed by sources other than up-link thermal, down-link thermal, and satellite intermodulation distortion	2,500 pWpO
Threshold carrier-to-noise ratio	7.5 dB
Baseband processing improvement factor	15.3 dB
Psophometric weighting improvement factor	2.0 dB
Array entries for year-to-year growth rate in demand (all identical)	12.0%
Satellite equivalent input noise temperature	1075 °K
Length of the study period	15 yrs
Satellite lifetime	7 yrs

Also included are the initial load, in erlangs, per station (erl) and the initial and end-of-period numbers of channels required to serve the load offered to a station that begins service during the first year of the study (ch).

Aside from the cost information it provides for later comparisons with terrestrial facilities, the Satellite Facility Matrix shows that under the lease option (see footnote on preceding page) the minimum-cost earth-station parameters are not so much a function of the total number of stations or of the total satellite load as of the per-station load. For example, entries on the main diagonal from upper-left to lower-right show that with a constant initial load per station of 1.8 erlangs the same, or nearly the same, earth-station parameter values are the minimum-cost values for numbers of stations all the way from 10 to 2000 and for total satellite loads from 40 to 8000 erlangs.

This is not surprising when the de-coupling effect of leasing satellite capacity as needed is considered. When any one developing nation must support the entire satellite segment, the tendency will be to so allocate the available satellite power as to postpone as long as possible the necessity of launching a second satellite. In this circumstance, as the number of stations and/or the total satellite load increases, there is a shifting economic optimum between increasing system capacity by increasing earth-station G/T and increasing satellite segment capacity. In effect, this circumstance produces an equivalent dollar-per-watt figure that is no longer a constant but is a function of the total load offered to the satellite.

G. CONCLUSIONS

With the Satellite System Design Program it has been shown that under present industry pricing:

1) The least-cost satellite system for national telephone and television communications to thin route (only a few circuits) users is accomplished using very small antennas at the small stations.

2) These stations will use antennas that are less than or equal to 15 ft. in diameter.

3) The diameter of the antenna at large stations need not be greater than 32 ft. Indeed, in some cases 20 ft. or 25 ft. diameters are the least-cost choice with regard to total system cost.

4) It is a misconception to believe that satellite power must be conserved at all cost. The optimum configuration for each of the three demand levels involved the launch and subsequent simultaneous use of more than a single active satellite. That is, it costs less to use more satellite power than to build larger (in terms of G/T) earth stations.

5) A key design parameter with regard to total system cost is the gain of the satellite transponder. This, of course, is not just another way of saying that satellite power should not be considered as the most costly resource. Although satellite power will decrease somewhat with sub-optimum transponder gains, the level of per-channel output power at the satellite is determined more by the G/T of the receive station than by the gain of the transponder. The optimum transponder gain will reduce the cost of the earth-station by permitting a lower up-link eirp.

6) The proper satellite for a given demand depends not only on the end-of-study, in-orbit power requirement but also, and more importantly, on the manner in which this requirement is reached. For example, the upper demand level requires 529 w of satellite power at the end of the 15th year, yet the minimum-cost satellite is one whose available end-of-life rf power is only 120 w.

7) It may be very advantageous in terms of total system cost to trade reduced transmission costs for increased costs of baseband signal processing per channel. In addition to the savings in the cost of power, as shown in Table 2-4, the narrower bandwidths will permit the satellite segment to handle more circuits without recourse to expensive schemes to reuse bandwidth.

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ATTACHMENT XI.3

ALASKA PUBLIC HEALTH SERVICE UNITS COMMUNITY PROFILE

The data included in this report were created from a file stored under the SPIRES Computer Information Retrieval System at the Stanford Center for Information Processing. These data are also available for interactive searching. Instructions for searching can be obtained at (415) 497-2755.

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ALASKA PUBLIC HEALTH SERVICE UNIT DEMOGRAPHIC PROFILES

The tables on the following pages have been compiled to assist in the planning of satellite medical telecommunications in Alaska. The tables, based on an earlier report by Daniel Allen and Carol Wilder, draw on a variety of sources for their data.

The tables are organized by Public Health Service Unit, which creates some problems in dealing with the population figures, as noted below.

The population data were obtained from the 1970 census. The native population figures were obtained from a variety of sources, including the 1969 "Estimates of Native Population in Villages, Towns and Boroughs of Alaska," and personal communications with U.S. Public Health Service personnel. The populations for each Health Service Unit obtained by summing the reported populations for all communities within the unit are often misleading. The total population for Alaska obtained this way is only 232,676 - some 70,000 short of the official census total of 302,173. We have tried to locate these "missing" Alaskans by developing a second population estimate based on the 1970 census district information. Although this is not completely accurate, as the census district and Health Service Unit boundaries do not always match, it does allow us to narrow the error.

As might be expected, most of the missing people are located in the more urban areas. The Anchorage unit has 49,269; Tanana has 11,768; and Mt. Edgecumbe has 5,959. (These figures were obtained by comparing unit populations calculated by summing the populations of all communities against estimates based on census district populations.)

Native population figures for urban areas seem to be our major problem area. We do not have these data for many cities, and those data we do have often appear to be wrong; however, we have not been able to identify more accurate projections. We include the best possible estimates from different sources at the bottom of each service unit listing.

Similarly, total native populations for each service unit calculated by summing the native populations of all native communities in the unit, are lower than most other estimates. The total native population for Alaska, calculated in this manner, is only 49,653, while the Office of Systems Development of the Indian Health Service estimates 52,300 and Alaska Native Enrollment for the Land Claims Act enumerates 60,214 eligible natives persons and 3827 ineligible ones (excluding those registered in other states).

Scheduled air service at airports was verified in the March 15, 1973 Offical Airline Guide.

Telecommunications

In the cities, local telephone networks are operated by municipal utility systems (e.g. Fairbanks Municipal Utilities System). In the bush, the major commercial carrier is the RCA Bush Phone network, which at the present reaches a small number of communities. Long line inter-city service for civilian use and connection with the Bell System in the "lower 48" states is mainly operated by RCA. RCA acquired in 1971 from the Air Force the ACS, a system linking major communities in the Eastern and Central sector of the state. In its bid for the ACS system, RCA proposed to provide reliable telephone service to as many bush villages as technically and economically feasible.

Only major cities have access to direct television. In a few communities cable service and educational stations offer taped programs.

Practically all communities have some kind of radiocommunication with neighboring cities, but technical difficulties (from hardware, the energy supply or the atmospheric conditions) make these links highly unreliable.

Data about telecommunications in this report came from the following sources:

For commercial public educational radio and television: "Broadcast Yearbook" and Television Factbook." They offer data about practically all stations on the basis of information provided by the stations and the FCC. An important source has also been the Teleconsult Report (ref. 2).

For radio and phone facilities in the villages: An extensive record is kept in the "Communications Facilities Handbook" issued by the Alaska Area Native Health Service. It includes information by service unit and village, longitude and latitude, the type of available communication, its frequency and call sign. RCA Alaska Communications has made available to the public information about their different accomplishments and plans. This material is available from RCA representatives.

An additional source reference used is the report prepared by Teleconsult Inc., "A Study of the Potential of Telecommunications and Educational Technology to Satisfy the Educational Communications Needs of the State of Alaska", Washington, D.C. 1972.

We feel these data are now about as accurate as we can make them from Stanford, and that it should now be reviewed by knowledgable Alaskans who can provide insight that those of us residing outside cannot. We will appreciate any comments, corrections or suggestions.

DEMOGRAPHIC AND COMMUNICATION SUMMARY OF THE NATIVE VILLAGES IN THE ALASKA PUBLIC HEALTH SERVICE UNITS

	TOTAL	Anch.	Barrow	Bethel	Kanak.	Kotz	Mt. Edg.	Tanana
Total Pop. in Communities with 25-1,000 res.	55,557	19,320	438	9,632	3,765	5,699	12,705	3,998
Native Pop. " " " " "	31,856	5,673	415	9,322	2,980	5,444	4,849	3,173
Communities with 25-1,000 residents	250	71	3	45	27	27	41	36
Native Communities with 25-1,000 residents	181	45	2	44	25	26	17	22
Transportation								
Native Communities (25-1,000 pop.):								
with scheduled air service	127	13	2	37	20	24	12	19
with road available	34	15	0	0	2	2	9	6
with regular ferry service	12	5	0	0	0	1	6	0
with at least one of the previous three	145	25	2	37	20	24	15	22
with none of the previous	36	20	0	7	5	2	2	0
with air strip but unsched. service	45	29	0	5	5	0	3	3
Communication								
Native Communities with HF Radio	142	26	1	43	25	24	3	20
" " " Telephone (Bush or Commercial)	81	15	4	20	9	17	10	6
" " " Satellite Radio	21	1	1	1	0	2	0	16

	TOTAL	Anch.	Barrow	Bethel	Kanak.	Kotz	Mt. Edg.	Tanana
Power								
Native Communities (25-1,000 pop.) with electric power available to the majority of the population	63	9	1	20	3	16	5	9
General Isolation								
Native Communities (25-1,000 pop.) with regular transportation service but no telephone	74	11	0	25	11	10	0	19
Native Communities (25-1,000 pop.) with neither regular transportation service nor telephone	6	0	1	0	2	1	1	1

GENERAL TABLES

GUIDE TO TABLES

The Alaskan communities in these tables are ordered alphabetically for each Public Health Service Unit (see Reference 16 above) with each population-type grouped separately (see POPULATION below):

*****NATIVE PLACES***** - %NAT GREATER THAN 33
*****NON-NATIVE PLACES***** - %NAT LESS THAN 34
*****UNPOPULATED PLACES***** - TOTAL EQUAL TO 0

The beginning of each new service unit is indicated by its name in the top left corner of that page. At the end of each service unit are notes pertaining to the reported population figures.

COMMUNITY

The community's primary name is given first. Any alternate names follow in parentheses. A name in parentheses preceded by "b:" is a BOROUGH name of which that community is a part.

POPULATION

TOTAL = TOTAL POPULATION FOR COMMUNITY
NAT = NATIVE POPULATION FOR COMMUNITY
%NAT = NATIVE POPULATION/TOTAL POPULATION

TRANSPORTATION

APT = AIRPORT
    0 = UNAVAILABLE
    1 = SCHEDULED SERVICE
    2 = UNSCHEDULED SERVICE
ROAD = ROADS
    0 = UNAVAILABLE
    1 = AVAILABLE
WATER= WATER TRANSPORTATION
    0 = UNAVAILABLE
    1 = FERRY
    2 = RIVERBOAT

COMMUNICATION

TEL = TELEPHONE
    0 = UNPLANNED
    1 = EXISTING RCA BUSH TELEPHONE
    2 = RCA BUSH TELEPHONE PLANNED, PHASE ONE
    3 = RCA BUSH TELEPHONE PLANNED, PHASE TWO
    4 = RCA BUSH TELEPHONE PLANNED, PHASE THREE
    5 = COMMERCIAL TELEPHONE AVAILABLE
HF = HIGH FREQUENCY RADIO AVAILABLE
    0 = UNAVAILABLE
    1 = PRIVATE
    2 = STATE
    3 = PUBLIC HEALTH SERVICE
    4 = BUREAU OF INDIAN AFFAIRS
    5 = UNKNOWN OWNER
TV = TELEVISION
    0 = UNAVAILABLE
    1 = CABLE TV WITH MAILED TAPES
    2 = ETV WITH MAILED TAPES
    3 = AIR FORCE TRANSLATOR
    4 = UNCERTAIN BUT PROBABLY AVAILABLE
    5 = COMMERCIAL TELEVISION
SAT = SATELLITE
    X = LINK AVAILABLE
    (BLANK = UNAVAILABLE)

POWER
    SOUR = SOURCE
        0 = UNAVAILABLE
        1 = INDIVIDUAL GENERATOR
        2 = DIESEL GENERATOR
        3 = TIE LINE
        4 = SCHOOL GENERATOR
        5 = REA
        6 = POWER AVAILABLE, SOURCE UNKNOWN
    DIST = DISTRIBUTION
        (SHOWN AS:
        % OF RESIDENTS WITH POWER)

HEALTH AIDES
        = NUMBER OF HEALTH AIDES ASSIGNED
        (BLANK = NONE)

COORDINATES
    LAT = LATITUDE
    LONG = LONGITUDE
    (ABOVE SHOWN AS "DEGREES.MINUTES")

NOTE:

BLANKS are to be treated as an indication of MISSING DATA except as noted under SATELLITE and HEALTH AIDES.

Anchorage PHS Unit

COMMUNITY	POPULATION			TRANSPORT			COMMUNICATION				POWER		HEALTH	COORDINATES	
	TOTAL	NAT	%NAT	APT	RD	WT	TEL	HF	TV	SAT	SO	DIS	AIDES	LAT	LONG
*****NATIVE PLACES *****															
Akhiok	115	113	99	2	0	0	4	1	0		6		1	56.56	154.10
Akutan	101	90	90	2	0	0	4	2	0		0	0	1	54.08	165.46
Atka	88	86	98	0	0	0	0	2	0		0	0	1	52.12	174.12
Belkofski	59	53	92	2	0	0	4	2	0		0	0	1	55.05	162.02
Chistochina	33	17	51	2	1	0	0	0	0		0	0			
Copper Center	206	93	45	2	1	0	5	0	0		0	0			
Dot Lake	42	29	69	2	1	0	5	0	0		0	0			
Eklutna	25	23	92	0	1	0	5	0	5		6				
English Bay	58	53	91	2	0	0	0	2	0		0	0	1	59.21	151.55
False Pass	62	58	92	2	0	0	0	5	0		1		1		
Gulkana	53	52	98	1	1	0	5	0	5		5	30			
Iliamna	58	23	41	1	0	0	2	0	0		0	0	1	59.45	154.55
Kaguyak (Alitak Fisheries)	59	33	56	0	0	0	0	0	0		0	0			
Kakhonak (Kokhnack)	88	67	76	2	0	0	1	5	0		0	0			
Karluk	98	95	97	2	0	0	4	1	0		1		1	57.34	154.27
King Cove	283	252	89	1	0	0	4	5	0		6	90			
Larsen Bay	109	91	82	1	0	0	4	1	0		1		1	57.32	153.58
Mcgrath	279	116	39	1	0	0	5	0	0		0	0	1	62.57	155.35
Mentasta Lake	68	64	94	0	1	0	0	0	0		1		1	62.54	143.45
Newhalen	88	83	94	2	1	0	1	0	0		0	0		59.43	154.54
Nikolai	112	101	90	2	0	0	0	5	0		0	0	1	62.58	154.09
Nikolski	57	52	91	1	0	0	5	2	0		0	0	1	52.56	168.51
Nondalton	184	182	99	2	0	0	1	2	0		0	0		59.58	154.51
Old Harbor	290	269	93	1	0	0	0	1	0		6	100	1	57.12	153.18
Ouzinkie	160	143	89	1	0	0	0	1	0		6	100	1	57.55	152.29
Pauloff Harbor (Pavlof)	39	38	97	2	0	0	4	5	0		0	0			
Pedro Bay	65	51	78	2	0	0	1	5	0		0	0			
Port Graham	107	96	90	2	0	0	4	1	0		0	0	1	59.21	151.49
Port Lions	227	184	81	1	0	1	5	0	1		6	61	1	57.52	152.53
Sand Point	360	265	74	2	0	0	5	5	0		0	0	1		
Squaw Harbor	65	52	80	2	0	0	0	5	0		0	0			
St. George Island	163	156	94	2	0	0	4	3	0		0	0		56.36	169.32
St. Paul Island	450	428	95	1	0	0	4	3	0	X	0	0		57.07	170.16
Tanacross	84	77	92	2	0	0	5	5	0		6		1	63.23	143.21
Tatitlek	111	107	96	2	0	0	4	2	0		0	0	1	60.52	146.41
Tyonek	232	221	95	2	1	0	5	5	5		6		1	61.04	151.08
Unalaska	178	121	69	2	0	0	5	3	0		6	100	1		
SUBTOTAL	4856	4034													

Anchorage PHS Unit

COMMUNITY	POPULATION TOTAL	NAT	%NAT	TRANSPORT APT	RD	WT	COMMUNICATION TEL	HF	TV	SAT	POWER SO	DIS	HEALTH AIDES	COORDINATES LAT	LONG
*****NON-NATIVE PLACES *****															
Adak Station	2249						5		3						
Anchor Point	102				1		5		5		6				
Anchorage	48031			1	1	1	5	1	5	X	6	100		61.31	149.53
Big Lake	36			2	1		5		5		6				
Birchwood	1219				1		5		5		6	100			
Butte	448				1		5		5		6	100			
Chitina	38	6	16	1	1		0		0						
Chugiak	489			2	1		5		5		6	100			
Clam Gulch	47						5		5						
Cold Bay	256	32	13	1			5		0						
Coopers Landing	31	1	3	2	1		5		5		6				
Cordova	1164	190	16	1		1	5		1		2	100			
Donnelly	6						5		5						
Eagle River	2437			2	1		5		5		6	100			
Elmendorf AFB (b:Anchorage)	6018			2	1		5		5		6	100			
Fire Lake	475				1		5		5		6	100			
Fritz Creek	27						5		0						
Ft. Richardson (b:Anchorage)	10751			2	1		5		5		6	100			
G. Phillips	50						0		0						
Gakona	88	23	26	2	1		5		0		6				
Girdwood	144				1		5		5						
Glen Alps	18						5								
Glennallen	363	37	11	2	1		5		5		6				
Halibut Cove	44						0		0						
Homer	1083	58	5	1	1		5		4		6	100			
Hope	51			2	1		5		5						
Houston	69	2	3		1		5		0		6				
Kachemak	76	12	16	2	1		0		0						
Kasilof	71			2	1		5		5						
Kenai	3533	175	5	1	1		5		5		6	100			
Kodiak	3798	642	17	2	1	1	5		1	X	6	100			
Kodiak Station	3052			2			5		1		6	100			
Long Island City	7														
Meakerville (Cordova)	349						5		1						
Mortana	33	4	12	2					0						
Moose Pass	53			2	1				0		6				
Ninilchik	134	18	13	2	1		5		5		6				
Northway	40	10	25	2	1		5	1	0		6		1		
Palmer (b:Matanuska-Susitna)	1140	38	3	2	1		5		5		6				
Peters Creek	340				1		5		5		6				
Sand Lake (b:Anchorage)	4168			2	1		5		5		6				

Anchorage PHS Unit

COMMUNITY	POPULATION			TRANSPORT			COMMUNICATION				POWER		HEALTH	COORDINATES	
	TOTAL	NAT	%NAT	APT	RO	WT	TEL	HF	TV	SAT	SO	DIS	AIDES	LAT	LONG
Seldovia	437	138	32	2	1	0	5	0	4		6				
Seward	1587	216	14	2	1	1	5		5		6				
Shemya Station	1131						5		3						
Soldotna	1202	16	1	2	1		5		5		6				
Spenard (b:Anchorage)	18089				1		5		5		6	100			
Sterling	30						5		5						
Summit	34	2	6	2	1		5		0						
Sutton	76	3	4	2	1		5		0		6				
Talkeetna	182	12	6	2	1		5		5		6				
Tetlin	140						2		0						
Tok	214	26	12	2	1		5		5		6				
Valdez	1005	150	15	2	1	1	5		1		3				
Wasilla	300	3	1	2	1		5		5		3				
Whittier	130	5	3		1	1	5		5		6	100			
Wildwood Station	750						5		5						
Willow	38			2	1		5		0		6				
Woody Island	41						5		0						
SUBTOTAL	117914	1819													
TOTAL	122770	5853													

Anchorage PHS Unit

*****NOTES*****

1. GREATER ANCHORAGE BOROUGH HAS ESTIMATED NATIVE POPULATION OF 4500
2. MATANUSKA-SUSITNA BOROUGH HAS ESTIMATED NATIVE POPULATION OF 270
3. POPULATION ESTIMATES:
    1. TOTAL POPULATION OF ALL PLACES LISTED ABOVE IS 122,580.
    2. AGGREGATE NATIVE POPULATION ESTIMATE IN THIS REPORT FOR THIS SERVICE UNIT IS 10,500. OTHER ESTIMATES ARE: A) 10,880 (SOURCE 12); B) 11,110 (SOURCE 15).
    3. OTHER NATIVE POPULATION ESTIMATES FOR ANCHORAGE ARE: A) 6,000 to 8,000 NATIVE RESIDENTS (SOURCE 13) AND B) 8,035 ELIGIBLE NATIVE RESIDENTS AND 1,448 INELIGIBLE CASES (SOURCE 14, LAND CLAIMS).
    4. NINILCHIK, NORTHWAY, CHITNA AND GAKONA ARE CONSIDERED BY THE INDIAN HEALTH SERVICE UNIT AS PREDOMINATELY NATIVE PLACES WITH FEW NON-NATIVES, FOLLOWING THE DEFINITION OF THE 1971 LAND CLAIMS ACT (SOURCE 16A).
4. POPULATION BY CENSUS DIVISION IS:

ALEUTIAN ISLANDS	8057
ANCHORAGE	126333
CORDOVA	1857
KENAI-COOK INLET	14250
KODIAK	9409
MATANUSKA-SUSITNA	6509
SEWARD	2336
VALDEZ-CHITNA	3098
TOTAL	171849

Barrow PHS Unit

COMMUNITY	POPULATION TOTAL	NAT	%NAT	TRANSPORT APT	RO	WT	COMMUNICATION TEL	HF	TV	SAT	POWER SO	DIS	HEALTH AIDES	COORDINATES LAT	LONG
*****NATIVE PLACES *****															
Barrow	2104	1906	90	1	0	0	1	3	1	X	6	14		71.17	156.47
Barter Island	123	108	88	1	0	0	5	0	0		6	20	1	70.08	143.36
Nooiksut	200						2		0						
Point Lay	200	200	100				5		0						
Wainwright	315	307	97	1	0	0	1	4	0		6	100	2	70.38	160.01
SUBTOTAL	2942	2521													
*****NON-NATIVE PLACES *****															
Deadhorse	163	15	9	1			5		0						
Prudhoe Bay	49	4	8	1			5		0		6				
Umiat	24	0	0				0		0		0	0			
SUBTOTAL	236	19													
*****UNPOPULATED PLACES *****															
Akeonik	0	0	0	0	0	0	0	0	0		0	0			
Atanik	0	0	0	0	0	0	0	0	0		0	0			
Beechy Point	0	0	0	0	0	0	0	0	0		0	0			
Colville	0	0	0	0	0	0	0	0	0		0	0			
Gorden	0	0	0	0	0	0	0	0	0		0	0			
Humphrey Point	0	0	0	0	0	0	0	0	0		0	0			
Meade River (Atkasuk)	0	0	0	0	0	0	0	0	0		0	0			
TOTAL	3178	2540													

*****NOTES*****

1. POPULATION ESTIMATES:
   1. TOTAL POPULATION OF PLACES LISTED ABOVE IS 2591.
   2. CENSUS DISTRICT POPULATION IS:
   BARROW 2663

Bethel PHS Unit

COMMUNITY	POPULATION TOTAL	NAT	%NAT	TRANSPORT APT	RO	WT	COMMUNICATION TEL	HF	TV	SAT	POWER SO	DIS	HEALTH AIDES	COORDINATES LAT	LONG
*****NATIVE PLACES *****															
Akiachak	312	300	96	1	0	0	1	4	0		0	0	2	64.54	161.26
Akiak	171	169	99	1	0	0	1	3	0		0	0	1	60.53	161.31
Akolmiut (Kasigluk,Nonapitchuk)	526	512	97	2	0	0	1	0	0		6	100			
Alakanuk	265	247	93	1	0	0	3	3	0		6	100	2	62.41	164.37
Aniak	205	170	82	1	0	0	5,1	3	0		2		1	61.54	159.32
Anvik	83	75	90	1	0	0	3	2	0		6	100	1	62.39	160.12
Atmautlak							1		0					60.53	162.27
Bethel	2416	1871	77	1	0	0	5,1	3	5,2	X	2	100		60.47	161.45
Chefornak	146	141	97	1	0	0	4	4	0		0	0		60.13	164.12
Chevak	387	376	97	1	0	0	1	3	0		6		2	61.32	165.35
Chauthbaluk	94	90	95	0	0	0	1	2	0		0	0	1	61.34	159.34
Crooked Creek	59	55	93	1	0	0	3	2	0		0	0	1	61.52	158.06
Eek	186	167	90	1	0	0	2	4	0		6	11	1	60.13	162.01
Emmonak (Kwiguk)	439	421	96	1	0	0	3	4,2	0		6	100	2	62.42	164.24
Grayling	139	136	98	1	0	0	3	4	0		6	100	1	62.57	160.03
Holy Cross	199	192	97	1	0	0	3	2	0		6	100		62.12	159.46
Hooper Bay	490	477	97	1	0	0	1	3	0		6	100		61.32	166.05
Kalskag	122	106	87	1	0	0	1	4,2	0		3	100	1	61.32	160.18
Kipnuk	325	320	98	1	0	0	4	3	0		6	45	2	59.56	164.03
Kongiganak	190	183	96	1	0	0	4	2	3		1	23	1	59.52	163.02
Kotlik	228	224	98	1	0	0	3	3	0		0	9	1	63.02	163.33
Kwethluk	408	390	96	1	0	0	1	3	0		6	100	2	60.49	161.26
Kwigillingok	148	145	98	1	0	0	4	4,2	0		0	0	1	59.51	163.08
Lime Village	25	25	100	0	0	2	0	0	0		0	0		61.21	155.28
Lower Kalskag	183	177	97	2	0	0	2	4,2	0		6	100	1	61.31	160.21
Marshall (Fortuna Ledge)	175	169	97	1	0	0	3	2	0		6	100	1	61.53	162.05
Mekoryuk	249	234	94	1	0	0	4	4,2	0		6	100	1	60.23	166.11
Moravian Home							1		0						
Mountain Village	419	394	94	1	0	0	3	3	0		6	100	2	62.05	163.43
Napakiak	259	254	98	1	0	0	1	4	0		0	0		60.42	161.57
Napaskiak	188	184	98	1	0	0	1	1	0		0	0	1	60.42	161.54
Newtok	114	111	97	1	0	0	4	1	0		0	0	1	60.56	164.38
Nightmuit (Nightmute)	127	122	96	2	0	0	0	4	0		0	0	1	60.28	164.44
Oscarville	41	38	92	2	0	0	1	4	0		0	0	1	60.43	161.46
Pilot Station	290	287	99	2	0	0	3	4	0		6	100	1	61.56	162.52
Pitka's Point	70	67	96	0	0	0	3	2	0		6		1	62.02	163.17
Quinhagok (Kwinhagak)	340	332	98	1	0	0	1	4	0		6	100	2	59.45	161.54
Russian Mission	146	138	95	1	0	0	3	3	0		0	0	1	61.47	161.19
Scammon Bay	166	166	100	1	0	0	1	4	0		6	100	1	61.51	165.35
Shageluk	167	158	95	1	0	0	3	4	0		6	100	1	62.41	159.34
Sheldon's Point	125	121	97	1	0	0	1	4	0		0	0	1	62.32	164.52

Bethel PHS Unit

COMMUNITY	POPULATION			TRANSPORT			COMMUNICATION				POWER		HEALTH	COORDINATES	
	TOTAL	NAT	%NAT	APT	RO	WT	TEL	HF	TV	SAT	SO	DIS	AIDES	LAT	LONG
Sleetmute	109	195	87	1	0	0	3	2	0		0	0	1	61.42	157.10
St. Mary's	384	350	91	1	0	0	3	3	0		6	100	2	62.03	163.10
Stony River	74	61	82	1	0	0	3	2	0		0	0	1	61.47	156.35
Toksook Bay	257	251	97	1	0	0	4	3	0		6	100	1	60.32	165.06
Tuluksok	195	193	99	1	0	0	1	3	0		1	25	1	61.06	160.58
Tuntutuliak	158	154	97	1	0	0	1	4	0		0	0	1	60.22	162.38
Tununok	274	270	99	1	0	0	4	4	0		6	100	1	60.37	165.15
SUBTOTAL	12073	11218													
*****NON-NATIVE PLACES *****															
Georgetown	12						3	5							
Red Devil	81	22	27	1			3	2	0				1	61.45	157.18
SUBTOTAL	93	22													
*****UNPOPULATED PLACES *****															
Andreafsky	0	0	0	0	0	0	0	0	0		0	0			
Chaneliak	0	0	0	0	0	0	0	0	0		0	0			
Emangut (Emangat)	0	0	0	0	0	0	0	0	0		0	0			
Hamilton	0	0	0	0	0	0	0	0	0		0	0			
Napaimute	0	0	0	0	0	0	0	0	0		0	0			
TOTAL	12166	11240													

*****NOTES*****

1. POPULATION ESTIMATES:
    1. TOTAL POPULATION OF PLACES LISTED ABOVE IS 12166.
    2. OTHER ESTIMATE FOR NATIVE POPULATIONS IS 11,880 (SOURCE 15).
2. CENSUS DISTRICT POPULATION IS:

BETHEL	7767
KUSKOKWIM	2306
WADE HAMPTON	3917
TOTAL	13990

Kanakanak PHS Unit

COMMUNITY	POPULATION TOTAL	NAT	%NAT	TRANSPORT APT	RO	WT	COMMUNICATION TEL	HF	TV	SAT	POWER SO	DIS	HEALTH AIDES	COORDINATES LAT	LONG
*****NATIVE PLACES *****															
Aleknagik	128	97	76	1	1	0	2	2	5		6		1	59.17	158.36
Chignik (Anchorage Bay)	83	67	81	1	0	0	0	2	0		6	24	1	56.18	158.24
Chignik Lagoon	70	65	93	1	0	0	4	2	0		0	0	1	56.20	158.29
Chignik Lake	117	115	99	2	0	0	4	2	0		1	21	1	56.14	158.47
Clark's Point	95	75	79	2	0	0	2	2	3		1	2	1	58.50	158.33
Dillingham (Kanakanak)	914	587	64	1	1	0	5	3	3		6			59.60	158.32
Egegik	148	74	50	1	0	0	1	1	0		0	0	1	58.13	157.22
Ekuk	51	50	98	1	0	0	2	2	0		1	2	1	58.49	158.33
Ekwok (Ekwak)	103	94	91	1	0	0	3	3	0		0	0	1	59.07	157.30
Goodnews Bay (Mumtrak)	218	210	96	1	0	0	1	4	0		6	100	1	50.70	161.35
Igiugig	36	34	95	1	0	0	1	2	0		4	5	1	59.20	155.55
Ivanof Bay	48	46	96	1	0	0	3	2	0		6	12	1	55.54	159.29
Kokhanok Bay									0						
Koliganek	142	134	94	1	0	0	2	2	3		6	6	1	59.48	157.25
Levelock	74	60	81	1	0	0	1	3	0		1	12	1	59.30	154.34
Manokotak	214	205	96	1	0	0	3	3	0		2	100	1	58.58	159.03
Nelson Lagoon	43	39	91	2	0	0	3	2	0		0	0	1	56.00	161.00
New Stuyahok	216	208	96	2	0	0	3	3	3		6	50	1	59.29	157.20
Pedro Point							1		0						
Perryville	94	90	96	1	0	0	3	3	0		0	0	1	55.54	159.09
Pilot Point	68	58	85	1	0	0	4	1	0		0	17	1	57.33	137.34
Platinum	55	48	87	1	0	0	1	2	0		0	0	1	59.00	161.49
Port Alsworth	100								0						
Port Heiden (Meshik)	66	58	88	1	0	0	5	2	0		0	0	1	56.55	158.41
Portage Creek	80			0	0	0	2	2	3		0	0	1	58.54	157.43
South Naknek	154	85	60	1	0	0	1	3	3		6	20	1	58.41	157.00
Togiak	383	377	98	1	0	0	3	3	0		6		2	59.04	160.24
Twin Hills	67	66	98	2	0	0	3	2	0		6	13	1	59.05	160.22
Ugashik	50						4								
SUBTOTAL	3817	2942													

Kanakanak PHS Unit

COMMUNITY	POPULATION			TRANSPORT			COMMUNICATION				POWER		HEALTH	COORDINATES	
	TOTAL	NAT	%NAT	APT	RO	WT	TEL	HF	TV	SAT	SO	DIS	AIDES	LAT	LONG
*****NON-NATIVE PLACES *****															
King Salmon	202	12	6	1			5		3						
Naknek	178	38	21	1			5	3	3		6	100	1	58.43	157.00
SUBTOTAL	380	50													
TOTAL	4197	2992													

*****NOTES*****

1. POPULATION ESTIMATES:
    1. TOTAL POPULATION OF PLACES LISTED ABOVE IS 4047.
    2. CENSUS DISTRICT POPULATION IS:

BRISTOL BAY	3485
BRISTOL BAY BOROUGH	1147
TOTAL	4632

2. OTHER ESTIMATES FOR TOTAL NATIVE POPULATION ARE: A) 3,550 (SOURCE 16D) AND B) 3,617 (SOURCE 14).

Kotzebue PHS Unit

COMMUNITY	POPULATION TOTAL	NAT	%NAT	TRANSPORT APT	RO	WT	COMMUNICATION TEL	HF	TV	SAT	POWER SO	DIS	HEALTH AIDES	COORDINATES LAT	LONG
*****NATIVE PLACES *****															
Ambler	169	159	94	1	0	1	0	2	0		6	15	1	67.05	157.52
Brevig Mission	123	118	96	1	1	0	0	3	0		0	0	1	65.20	166.29
Buckland	104	103	99	1	0	0	1	5	0		0	0	1	65.59	161.08
Candle (Kiwalik Landing)	12	10	83	0	0	0	0	0	0		0	0			
Deering	85	83	98	1	0	0	1	3	0		4		1	66.04	162.42
Diomede (Little Diomede)	84	82	98	0	0	0	1	0	0		0	0	1	65.45	168.55
Elim	174	168	97	1	0	0	1	4	0		6	100	1	64.37	162.15
Gambell	372	356	96	1	0	0	4	3	0		6	100	2	63.47	171.45
Golovin	117	111	95	1	0	0	1	4	0		0	0	1	64.33	163.02
Kiana	278	268	97	1	0	0	4	4	0		6	100	2	66.58	160.26
Kivalina	188	183	97	1	0	0	4	2	0		6	100	1	67.58	164.32
Kobuk							4		0					66.55	156.52
Kotzebue	1696	1338	79	1	0	0	5	3	0	X	6	100		66.54	162.35
Koyuk	122	121	100	1	0	0	1	2	0		6	100	1	64.56	161.09
Noatak	293	286	98	1	0	0	4	2	0		6	100	1	67.34	162.58
Nome	2488	1534	62	1	1	0	5	3	0,1	X	6	100		64.30	165.25
Noorvik	462	443	97	1	0	0	4	3	0		6	100	2	66.50	161.03
Point Hope	386	369	97	1	0	0	5	3	0		6	100	2	68.21	166.47
Savoonga	364	354	97	1	0	0	4	3	0		6	100	1	63.42	170.29
Selawik	429	418	98	1	0	0	1	3	0		6	100	2	66.36	160.00
Shaktoolik	151	144	95	1	0	0	1	4	0		6	100	1	64.20	161.09
Shishmaref	267	249	93	1	0	0	5	2	0		6	100	2	66.15	166.04
Shungnak City	165	160	97	1	0	0	4	3	0		6	100	1	66.52	157.09
Shungnak Village	56	54	96	0	0	0	0	0	0		6	100		66.52	157.09
St. Michael	207	192	92	1	0	0	1	3	0		6	100	1	63.29	162.02
Stebbins	231	223	97	1	1	0	1	4,2	0		6	100	1	63.31	162.17
Teller	220	192	87	1	0	0	5	3	0		0	34	1	65.16	166.22
Unalakleet	434	403	92	1	0	0	5	4	0		6		1	63.52	160.47
Wales	131	121	92	1	0	0	1	2	0		6		1	65.37	168.05
White Mountain	87	84	96	1	0	0	0	3	0		0	1	1	64.41	163.24
SUBTOTAL	9895	8326													

Kotzebue PHS Unit

COMMUNITY	POPULATION TOTAL	 NAT	 %NAT	TRANSPORT APT	 RO	 WT	COMMUNICATION TEL	 HF	 TV	 SAT	POWER SO	 DIS	HEALTH AIDES	COORDINATES LAT	 LONG
*****NON-NATIVE PLACES *****															
Bornite	100			1			4								
Cape Lisburne	83						1		3						
Northeast Cape							5								
SUBTOTAL	183	0													
TOTAL	10078	8326													

*****NOTES*****

1. POPULATION ESTIMATES:
    1. TOTAL POPULATION FOR PLACES LISTED ABOVE IS 9978.
    2. CENSUS DISTRICT POPULATION IS:

KOBUK	4434
NOME	5749
TOTAL	10183

Mt. Edgecumbe PHS Unit

COMMUNITY	POPULATION TOTAL	NAT	%NAT	TRANSPORT APT	RD	WT	COMMUNICATION TEL	HF	TV	SAT	POWER SO	DIS	HEALTH AIDES	COORDINATES LAT	LONG
*****NATIVE PLACES *****															
Angoon	400	377	94	1	0	0	5	2	0		6	100	2	57.30	134.35
Craig	272	153	56	1	0	0	5	0	0		0	0	1	55.28	133.09
Hoonah	748	539	72	1	0	1	5	0	0		6	20	3	58.06	135.26
Hydaburg	214	189	88	1	0	0	5	5	0		1	100	1	52.12	
Kake	448	406	91	2	0	0	5	2	0		0	0	3	56.58	133.56
Klawock	213	195	92	1	1	0	5	0	0		0	0		55.33	133.05
Klukwan	103	92	89	0	1	0	5	0	0		0	0		59.24	135.53
Metlakatla	1050	860	81	2	1	0	5	0	0		6	16			
Point Baker	50						2		0						
Saxman	135	99	73	2	1	0	5	0	0		0	0			
Yakutat	190	157	82	1	0	0	5	0	0		6	25	2		
SUBTOTAL	3823	3067													
*****NON-NATIVE PLACES *****															
Annette	195	22	11	1			5		0						
Auke Bay	490						5		5						
Campbell	40	6	15	2			5								
Cape Pole	123	15	12	2			2		0						
Clover Pass (b:Ketchikan)	261						5		0						
Douglas (b:Juneau)	1243						5		5						
Edna Bay	112	3	3	2			5		0						
Elfin Cove	49	2	4	2			0		0						
Fritz Cove (b:Juneau)	296						5		5						
Gustavus	64	4	6	2			5		0						
Haines	463	110	24	1	1	1	5		5,1						
Herring Cove (b:Ketchikan)	114						5		0						
Hyder	49			2					0						
Juneau	6050			1	1	1	5		5	X	6	100			
Kasaan	30	8	27	2			3		0						
Ketchikan	6994			1	1	1	5		1		6	100			
Lemon Creek (b:Juneau)	1042						5		5						
Lena Beach (b:Juneau)	300						5		5						
Lower Mendenhall Valley	1109						5		5						
Mendenhall Flats	164						5		5						
Mountain Point (b:Ketchikan)	459						5		1						
Mt. Edgecumbe (b:Sitka)	835						5		1					57.03	135.22
Mud Bay (b:Sitka)	103								0						
Myers Chuck	37			2			3		0						
North Douglas (b:Juneau)	538						5		5						
Pelican City	133	27	20	1			5		0						

	TOTAL	NAT	%NAT	APT	RO	WT	TEL	HF	TV	SAT	SO	DIS	AIDES	LAT	LONG
Peninsula Point (b:Ketchikan)	175						5		1						
Pennock Island (b:Ketchikan)	78						5		5						
Petersburg	2042	295	15	1	1	1	5		1						
Port Alexander	36	3	9	2		1	0		0						
Port Chilcoot (b:Haines)	220	52	24				5		0						
Port Higgins	189						5		5						
Scow Bay (b:Petersburg)	238						5		0						
Sitka	3370	836	25	1	1	1	5		1		6	100			
Skagway	675	41	6	1	1	1	5		1		6	100			
Tenakee Springs	86	10	12	2		1	0		0						
Thorne Bay	443	7	2	2		1	5		0						
Upper Mendenhall Valley	1815						5		5						
Ward Cove (b:Ketchikan)	105						5		1						
West Petersburg	36						5		0						
Wrangell	2029	421	21	1	1	1	5		1		6	100			
SUBTOTAL	32830	1862													
TOTAL	36653	4929													

*****NOTES*****

1. GREATER JUNEAU BOROUGH NATIVE POPULATON ESTIMATED AT 1850.
   ANOTHER ESTIMATE IS 2,337 (SOURCE 14).
2. GREATER SITKA BOROUGH NATIVE POPULATION ESTIMATED AT 1900.
   ANOTHER ESTIMATE IS 1,864 (SOURCE 14).
3. OTHER ESTIMATE FOR TOTAL NATIVE POPULATION IS 17,500 (SOURCE 14, QUOTED IN 16F).
4. POPULATION ESTIMATES:
   1. TOTAL POPULATION OF PLACES LISTED ABOVE IS 36,603.
   2. POPULATION BY CENSUS DIVISION IS:

ANGOON	503
HAINES	1504
JUNEAU	13556
KETCHIKAN	10041
OUTER KETCHIKAN	1676
PRINCE OF WALES	2106
SITKA	6106
SKAGWAY-YAKUTAT	2157
WRANGELL	4913
TOTAL	42562

Tanana PHS Unit

COMMUNITY	POPULATION			TRANSPORT			COMMUNICATION				POWER		HEALTH	COORDINATES	
	TOTAL	NAT	%NAT	APT	RO	WT	TEL	HF	TV	SAT	SO	DIS	AIDES	LAT	LONG
*****NATIVE PLACES *****															
Allakaket	174	168	97	1	0	0	0	2	0	X	6	100	1	66.34	152.38
Anaktuvuk Pass	99	97	98	1	0	0	0	2	0	X	0	0	1	69.08	151.45
Arctic Village	85	82	97	1	0	0	0	2	0	X	0	0	1	68.08	145.32
Beaver	101	86	86	1	0	0	4	4	0	X	0	0	1	66.21	147.23
Birch Creek	50						4								
Cantwell	62	43	69	2	1	0	5	1	0		0	0		66.15	145.48
Chalkytsik	130	123	95	1	0	0	0	2	0	X	0	0	1	66.39	143.43
Chicken	25	25	100	0	0	0	0	0	0		0	0			
Circle	54	32	59	1	1	0	4	2	0		6		1	65.49	144.03
Eagle	85	65	76	1	1	0	0	2	0	X	0	0	1	64.47	141.12
Fort Yukon	448	376	84	1	0	0	5	3	2	X	6			66.34	145.16
Galena	302	265	88	1	0	0	5	3	3	X	2	100	2	64.44	156.56
Hughes	85	73	86	1	0	0	3	2	0	X	1	100	1	66.03	154.15
Huslia	159	151	95	1	0	0	3	2	0	X	6	100	1	65.41	156.24
Kaltag	206	193	94	1	0	0	1	2	0		6	100	1	64.20	158.43
Koyukuk	124	121	98	1	0	0	3	3	0	X	0	0	1	64.53	157.42
Minto	168	159	95	1	1	0	4	2	5		6	100	1	65.07	149.19
Nenana	362	142	39	2	1	0	5	0	5		6	100	1	64.34	149.05
Nulato	308	298	97	1	0	0	3	2	0	X	6	100	1	64.43	158.06
Rampart	36	21	58	1	0	0	4	2	0		0	0	1	65.30	150.10
Ruby	145	134	92	1	0	0	3	2	0	X	0	0	1	64.45	155.30
Stevens Village	74	72	97	1	0	0	4	1	0	X	0	0	1	66.01	149.06
Tanana	450	350	77	1	0	0	5	3	0	X	2	100			
Venetie	112	108	96	1	0	0	0	4	0	X	4	5	1	67.01	146.25
Wiseman	10	10	100	0	0	0	0	0	0		0	0			
SUBTOTAL	3854	3194													
*****NON-NATIVE PLACES *****															
Anderson City	362	7	2	1	1		5								
Aurora-Johnson (b:North Star)	1464				1		5				6	100			
Bettles Field	57	14	25	1			5	1	0						
Central	26			1	1		0		0						
College (b:North Star)	3434				1		5	1	5	X	6	100			
Delta Junction	703	10	1	1	1		5		5		6	100			
Eielson AFB	6149			2	1		5	1	5		6	100			
Ester (b:North Star)	264			2	1		5		5		6	100			
Fairbanks (b:North Star)	15173			1	1		5,1		5		6	100			
Fort Greely	1820			2	1		5		5		6	100			
Fort Wainwright (b:North Star)	9097			2	1		5		5		6	100			
Graehl (b:North Star)	349				1		5		5		6	100			

Tanana PHS Unit

COMMUNITY	POPULATION TOTAL	NAT	%NAT	TRANSPORT APT	RO	WT	COMMUNICATION TEL	HF	TV	SAT	POWER SO	DIS	HEALTH AIDES	COORDINATES LAT	LONG
Healy	79	10	12	2	1		5		5		6	100			
Lemeta-Johnson (b:North Star)	1[illegible]				1		5		5		6	100			
Manley Hot Springs	265	35	13	2	1		4		0						
North Pole	34	11	33		1		5		5		6	100			
Suntrana	67	11	16	2					5						
Usibelli	102	14	14	2	1				5						
Usibelli Mine	65								5						
SUBTOTAL	40828	112													
*****UNPOPULATED PLACES *****															
Yutana Barge Lines	0	0	0	0	0	0	0	0	0		0	0			
TOTAL	44682	3306													

*****NOTES*****

1. NORTH STAR BOROUGH HAS ESTIMATED NATIVE POPULATION OF 2180
2. ESTIMATES OF NATIVE POPULATION FOR TOTAL SERVICE AREA ARE:
   A) 6,600 (SOURCE 16G) AND B) 8,076 (SOURCE 14).
3. ESTIMATE FOR TOTAL NATIVE POPULATION OF FAIRBANKS IS 3,005 (SOURCE 14).
4. TOTAL POPULATION ESTIMATES:
   1. TOTAL POPULATION OF PLACES LISTED ABOVE IS 44,711
   2. POPULATION BY CENSUS DIVISION IS:

FAIRBANKS	45864
SOUTHEAST FAIRBANKS	4179
YUKON-KOYUKUK	4752
UPPER YUKON	1684
TOTAL	56479

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4. Summary of a Questionnaire Send to Health Aides, CHAP (A-ONA) 1971.

5. Alaska Community Inventory, Federal Field Committee for Development Planning in Alaska, 1971.

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14. Alaskan Tribal Systems - IADC 554-401A Alaska Federation of Natives (Date run 8/06/73).

15. Office of System Development, Alaska Native Health Service, undated document

16. Service Unit Operative Plan FY 1974, Alaska Area Native Health Service, Indian Health Service, PHS-HMSHA-HEW.
    a) Alaska Native Medical Center and Anchorage Service Unit
    b) Barrow Service Unit
    c) Bethel Service Unit
    d) Kanakanak Service Unit
    e) Kotzebue Service Unit
    f) Mt. Edgecumbe Service Unit
    g) Tanana Service Unit

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EXAMPLE OF AN INTERACTIVE SEARCH INTO THE ALASKA FILE IN THE SPIRES SYSTEM

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COMMAND ? spires
WELCOME TO SPIRES-2, OSVALDO          ...IF IN TROUBLE, TRY 'HELP'

SELECT ALASKA
FIND NATIVE POPULATION <1000 AND >25 AND PHS UNIT BETHEL
RESULT:    44 COMMUNITY(S)
STORE RESULT.NATIVE.VILLAGE.BETHEL
RESULT.NATIVE.VILLAGE.BETHEL" PUT IN ORVYL FILE SYSTEM.
FIND @RESULT.NATIVE.VILLAGE.BETHEL AND AIR 1
RESULT:    37 COMMUNITY(S)
FIND @RESULT.NATIVE.VILLAGE.BETHEL AND AIR 2
RESULT:     5 COMMUNITY(S)
FIND @RESULT.NATIVE.VILLAGE.BETHEL AND ROAD AVAILABLE
ZERO RESULT.
FIND @RESULT.NATIVE.VILLAGE.BETHEL AND WATER-TRANS 1
ZERO RESULT.
FIND @RESULT.NATIVE.VILLAGE.BETHEL AND NOT AIR 1 AND NOT ROAD 1 AND
     NOT WATER TRANSPORTATION 1
RESULT:     7 COMMUNITY(S)
AND TELEPHONE PROBABLY UNAVAILABLE
RESULT:     7 COMMUNITY(S)
FIND @RESULT.NATIVE.VILLAGE.BETHEL AND RADIO AVAILABLE
RESULT:    43 COMMUNITY(S)
FIND @RESULT.NATIVE.VILLAGE.BETHEL AND SATELLITE RADIO
ZERO RESULT.
FIND @RESULT.NATIVE.VILLAGE.BETHEL AND POWER AVAILABLE AND POWER
     DISTRIBUTION >50
RESULT:    20 COMMUNITY(S)
FIND @RESULT.NATIVE.VILLAGE.BETHEL AND (AIR 1 OR ROAD 1 OR WATER-
     TRANS 1)
RESULT:    37 COMMUNITY(S)
AND TELEPHONE PROBABLY UNAVAILABLE
RESULT:    35 COMMUNITY(S)

LOGOFF
```

*** EXPLAIN ALASKA ***

This SUBFILE contains Profiles of Alaskan Communities. An introduction to the file in terms of its data and sources can be found by typing the command 'SELECT ALASKA NOTES' and then the command 'DISPLAY G-1'. For additional information on that subfile, type 'EXPLAIN SUBFILE ALASKA NOTES'.

The ALASKA subfile contains the following major categories of information:

1. Community Name(s)
2. Population
3. Public Health Service Data
4. Transportation
5. Communication
6. Electrical Power
7. Geographic Location
8. Geographic Groupings
9. Record Add/Update Information
10. Community Identifier

An additional category of information is available under the ALASKA NOTES subfile:

11. Appendix Information (General Description, Footnotes, References)

The following outline details all of the data elements available under the subfiles. UPPER CASE names are the data elements. Additional UPPER CASE names in parentheses are legal abbreviations which may be used. An '*' means the data element is required for each record (Community):

1. Community Name(s)
    a. COMMUNITY*(COMM,C,NAME,NAM,N,CN)
    b. ALTERNATE-NAME (AN)
2. Population
    a. POPULATION-TYPE*(POP-TYP,PT)
    b. POPULATION (POP,P,TOTAL)
    c. NATIVE-POP (NATIVE.POP,NAT-POP,NAT,NPOP,NP)
    d. NATIVE-PERCENT (NAT-PER,NPER,NATIVE%,NAT%,N%,%NAT)
3. Public Health Service Data
    a. PHS-UNIT*(PHSU,PU,UNIT,U)
    b. HEALTH-AIDES*(HEA-AID,HA,AIDES,AID,ADS)
4. Transportation
    a. AIRPORT (APT,AIR,A)
    b. ROADS (ROAD,RO)
    c. WATER-TRANS (WAT,WT,W)
5. Communication
    a. TELEPHONE (TELE,TEL,T)
    b. RADIO (RAD,RA,HF)
    c. TELEVISION (TV)
    d. SATELLITE (SAT,S)
6. Electrical Power
    a. POWER (POWER-SOURCE,POW,PO.PS,SOURCE,SO)
    b. POWER-DIST (POWER.DIST,POW-DIS,PD,DISTRIBUTION DIST,DIS)

7. Geographic Location
   a. LATITUDE (LAT,LA)
   b. LONGITUDE (LONG,LON,LO)
8. Geographic Groupings
   a. CENSUS-DISTRICT (CEN-DIS,CE)
   b. BOROUGH (BOR,B)
   c. OTHER-REGION (OTH-REG,O)
9. Record Add/Update Information
   a. CREATION-DATE (CRE-DAT,CD)
   b. MODIFICATION-DAT (MOD-DAT,DATE,DAT,MD,D)
10. Community Identifier
   a. COMMUNITY-ID*(COMM-ID,CID,CI,ID)
11. Appendix Information
   a. NOTE-ID (NOTES,NOTE,NI)
   b. NOTE-TYPE (NOT-TYP,NT)
   c. COMMUNITY-REF (COMM-REF,CR)
   d. NOTE-KEYWORD (NOT-KEY,NK)
   e. NOTE-TEXT (NOT-TEX,TEXT,T)

COMMUNITY-ID is the key of each record in the file. It is required by all DISPLAY, TRANSFER, and UPDATE commands. CREATION-DATE is the date the Community record was first ADDed to the file. MODIFICATION-DAT is the date the record was last manipulated by an ADD or UPDATE command.

'EXPLAIN ALASKA NOTES' for more information about category 11. Remember that 11.b.-11.e are available only under the ALASKA NOTES version of the subfile, unless the command 'FORMAT WITH NOTES' is given to specify the 'WITH NOTES' Output Format. 'SHOW FORMATS' for other available formats.

All data elements are available as Search Terms ('FIND' command) except COMMUNITY-ID and elements 11.b.-11.e.

The following data elements have THESAURUS's describing the simple and combined search values which may be used with them:
   AIRPORT (4.a), ROADS(4.b.),
   TELEPHONE(5.a.), RADIO(5.b.),
   POWER(6.a).

Type the command 'THESAURUS data-element-name' and these values will be displayed to you in WYLBUR.
For example: 'THE AIRPORT' puts the following into WYLBUR:

```
1.
2.     A. Available
3.     A.1 Scheduled Service
4.     A.2 Unscheduled Service
5.     U. Probably Unavailable
6.     U.0 Unavailable
7.     U.9 Missing Data
```

The outline CODES show the relationship of values to one another, but ONLY the values may be used in searching. For example, in WYLBUR line #2, the combined search value 'Available' with the code 'A.' can be used to find the simple search values under 'A.1' & 'A.2'. Thus the command 'FIND AIR AVAILABLE' results in communities with:
   'AIRPORT = Scheduled Service'
or 'AIRPORT = Unscheduled Service'.

While outline CODES may not be used in searching, the number portion of any simple value may be used, optionally separated by commas to specify groups. Thus, 'FIND AIR 0' is the same as 'FIND AIR UNAVAILABLE', and 'FIND AIR 1,2' is the same as 'FIND AIR AVAILABLE'.

Simple values may be abbreviated in searching by use of the pound sign (#), but beware of ambiguities and do not use abbreviations which conflict with compound search values, which may not be abbreviated.
Thus, 'FIND A SCH#',
      'FIND A SCHEDULED #',
  and 'FIND A SCHEDULED SERVICE' are all equivalent.

But 'FIND AIR U#' would result in occurrences of 'Unavailable' as well as 'Unscheduled Service'. And 'FIND AIR AVA#' would not work because 'Available' is a compound search value.

ATTACHMENT XI.4

Parameters and Costs of the Least-Cost Satellite System Configuration

The satellite system analyzed has a satellite beamwidth of 5° x 7°, similar to either the Canadian Anik Satellite or RCA's proposed satellite. Within this coverage pattern it is assumed that 200 small ground stations are installed each year for the first five years. Each station starts with a requirement for 0.4 erlangs of traffic, about one three-minute call every 8 minutes and grows at a rate of 11% per year.

It is also assumed that two large stations are added each year for the first five years. The large station traffic starts at 40 erlangs and also grows at a rate of 11% per year.

Under these conditions, the optimum station design for the small stations has a 10 ft. antenna, a 350° K pre-amplifier, and a 5 watt amplifier. The initial installed capital cost for these components (not including channelizing equipment) would be $10,905.

The channelizing equipment assumed for this analysis provides a Test-Tone-to-Noise ratio of 40 dB with a Carrier-to-Noise threshold of 7.5 dB in a 20 kHz Bandwidth.

Additional computer runs show this configuration to be at or near optimum for a 2 to 1 variation in number of stations or telephone traffic.

For the Indian Health Service it is appropriate to design a station that approximates this configuration and incorporates the ability to develope towards the configuration with time.

The following pages of this attachment are the computer summary of the optimum configuration.

PARAMETERS AND COSTS
OF THE
LEAST-COST SATELLITE SYSTEM CONFIGURATION

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SATELLITE SEGMENT PARAMETERS AND COSTS.................................. 8

LINK CALCULATIONS... 9

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                              ***SUMMARY***


                          *CHANNEL QUALITIES*

(GIVEN IN TERMS OF WORST-CASE TOTAL ALLOWED NOISE POWER IN THE BASEBAND)
(SEE FOOTNOTE 3A)
  FOR L-TO-L CHANNELS =  10000 PWPO   FOR S-TO-L CHANNELS = 100000 PWPO
  FOR S-TO-S CHANNELS = 100000 PWPO   FOR L-TO-S CHANNELS = 100000 PWPO


                            *SYSTEM COSTS*

                                                             91.820 $M
TOTAL PRESENT WORTH                                          71.254 $M
SATELLITE SEGMENT PRESENT WORTH                               1.870 $M
TOTAL PRESENT WORTH OF ALL LARGE STATIONS                    18.695 $M
TOTAL PRESENT WORTH OF ALL SMALL STATIONS
IF THE TOTAL COST OF THE SYSTEM WERE RECOVERED THROUGH UNIFORM ANNUAL
PER-STATION CHARGES, THESE CHARGES WOULD BE:
  ANNUAL CHARGE PER OPERATING LARGE STATION     $ 125293.
  ANNUAL CHARGE PER OPERATING SMALL STATION     $   6855.
IF THE TOTAL COST OF THE SYSTEM WERE RECOVERED THROUGH UNIFORM ANNUAL
PER-STATION CHARGES, THESE CHARGES WOULD BE:
  ANNUAL CHARGE PER CHANNEL AT LARGE STATIONS     $  767.
  ANNUAL CHARGE PER CHANNEL AT SMALL STATIONS     $ 1549.
IF THE TOTAL COST OF THE SYSTEM WERE RECOVERED THROUGH UNIFORM ANNUAL
PER-BUSY-HOUR-ERLANG CHARGES, THESE CHARGES WOULD BE:
  ANNUAL CHARGE PER BUSY-HOUR ERLANG AT LARGE STATIONS    $  869.
  ANNUAL CHARGE PER BUSY-HOUR ERLANG AT SMALL STATIONS    $ 2120.
IF THE TOTAL COST OF THE SYSTEM WERE RECOVERED THROUGH UNIFORM CHARGES
PER CALL-MINUTE, THE CHARGES WOULD BE (SEE FOOTNOTE 1, PAGE 3):
  CHARGE PER CALL-MINUTE AT LARGE STATIONS    $ 0.04
  CHARGE PER CALL-MINUTE AT SMALL STATIONS    $ 0.34
   (THE APPROPRIATE CHARGE IS PAID BY BOTH CONVERSANTS)


                 *SUB-SYSTEM PARAMETERS AND COSTS*

SMALL STATION:
  ANTENNA DIAMETER = 10 FT         RCVR NOISE TEMPERATURE =  350 DEG K
  POWER RATING OF INITIAL POWER AMPLIFIER =      5 W
  INITIAL INSTALLED CAPITAL COST (SEE FOOTNOTE 2)              $  10905.
LARGE STATION:
  ANTENNA DIAMETER = 20 FT         RCVR NOISE TEMPERATURE =   97 DEG K
  POWER RATING OF INITIAL POWER AMPLIFIER =   100 W
  INITIAL INSTALLED CAPITAL COST (SEE FOOTNOTE 2)              $ 105300.
SATELLITE SEGMENT:
  TOTAL RATED SATURATED OUTPUT POWER PER SATELLITE                120 W
  SATELLITE LIFETIME                                              7 YRS*

  REQUIRED SATELLITE LAUNCHES, IN UNITS, VERSUS TIME (FROM LEFT TO
  RIGHT, BEGINNING WITH YEAR 1 OF THE STUDY PERIOD)
       2    0    0    0    0    0    0    2    0    0    0    0    0    2

  TRANSPONDER GAINS (SEE FOOTNOTE 3B)
     FOR L-TO-L CARRIERS = 115.2 DB      FOR S-TO-L CARRIERS = 113.4 DB
     FOR S-TO-S CARRIERS = 124.2 DB      FOR L-TO-S CARRIERS = 122.4 DB
```

FOOTNOTES TO SUMMARY

1. THE CHARGE PER CALL-MINUTE ($/C-M) IS CALCULATED USING THE FOLLOWING FORMULA:

```
          $/C-M = ($/BHE-Y)*(E/(C-M/H))*(Y/D)*(D/H)*(BHE/AE)

WHERE:  $/BHE-Y = THE ANNUAL (OR, PER-YEAR) CHARGE PER BUSY-HOUR ERLANG
     E/(C-M/H) = A FACTOR TO CONVERT ERLANGS TO CALL-MINUTES
                 PER HOUR (=1/60)
           D/Y = THE NUMBER OF BUSY DAYS PER YEAR (=250)
                 (THIS FACTOR ACCOUNTS FOR THE FACT THAT ON WEEKENDS
                 AND SOME HOLIDAYS THE BUSY HOUR LOAD DROPS SHARPLY
                 FROM ITS NORMAL BUSINESS DAY LEVEL)
           H/D = THE NUMBER OF HOURS PER DAY DURING WHICH THE MAJORITY
                 OF THE CALLS ARE MADE (=8)
        BHE/AE = THE RATIO OF THE OFFERED LOAD DURING THE BUSY HOUR
                 (BUSY-HOUR ERLANGS), IN ERLANGS, TO THE AVERAGE HOURLY
                 LOAD PER 8-HOUR DAY (AVERAGE ERLANGS), IN ERLANGS (=5)
```

2. THE CAPITAL COST OF EARTH-STATION EQUIPMENT INCLUDES A VOLUME DISCOUNT ON THE SINGLE-ITEM COST OF IDENTICAL ITEMS PURCHASED IN THE SAME YEAR. FOR N UNITS THE RATIO (R) OF THE PER-UNIT COST TO THE SINGLE-ITEM COST IS:

```
                    R = 0.92**(LOG(N)/LOG(2))
```

WHERE ** DENOTES EXPONENTIATION.

3. IN THIS PARAGRAPH L STANDS FOR LARGE STATIONS AND S STANDS FOR SMALL STATIONS. THEREFORE,

A. 'FOR L-TO-S CHANNELS' MEANS 'THE QUALITY OF ALL CHANNELS FROM A LARGE STATION TO A SMALL STATION'.

B. 'FOR L-TO-S CARRIERS' MEANS 'THE GAIN OF TRANSPONDERS THAT HANDLE ONLY THOSE CARRIERS BEING TRANSMITTED FROM A LARGE STATION TO A SMALL STATION'.

(THE PHRASES USING L-TO-L, S-TO-L, AND S-TO-S HAVE SIMILAR MEANINGS.)

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                    ***SMALL STATION DATA SHEET***


            *CIRCUIT DEMAND AND STATION COST FIGURES*

THE DEMAND OFFERED TO A SMALL STATION FOR SERVICE         0.125 ERLANGS
  WITH ALL OTHER SMALL STATIONS DURING THE FIRST YEAR
  THE STATION IS IN OPERATION

THE DEMAND OFFERED TO A SMALL STATION FOR SERVICE         0.275 ERLANGS
  WITH ALL LARGE STATIONS DURING THE FIRST YEAR THE
  STATION IS IN OPERATION

THE PERCENT INCREASE IN DEMAND OFFERED TO A SMALL STATION FOR SERVICE
TO ALL OTHER STATIONS DURING EACH SUCCEEDING ONE-YEAR PERIOD OF ITS SER-
VICE LIFE (FROM LEFT TO RIGHT, BEGINNING WITH THE FIRST YEAR THE STA-
TION IS IN OPERATION):
       11% 11% 11% 11% 11% 11% 11% 11% 11% 11% 11% 11% 11% 11% 11%


THE NUMBER OF NEW STATIONS THAT BEGIN SERVICE IN EACH SUCCEEDING YEAR OF
THE STUDY PERIOD (FROM LEFT TO RIGHT, BEGINNING WITH YEAR 1):
       200 200 200 200 200   0   0   0   0   0   0   0   0   0   0

INITIAL CAPITAL COST PER STATION                               $   8835.
INITIAL INSTALLATION COST PER STATION                          $    880.
INITIAL MISCELLANEOUS COST PER STATION                         $   1190.
INITIAL INSTALLED COST PER STATION                             $  10905.


                        *ANTENNA*
DIAMETER                                                          10 FT
CAPITAL COST (WITH VOLUME DISCOUNT)                            $    634.
     (BASED ON NON-DISCOUNTED, SINGLE ITEM COST OF  $   1200.)
INSTALLATION COST                                              $    180.
ANNUAL OPERATIONS AND MAINTENANCE COST                         $    180.
MISCELLANEOUS COSTS                                            $    240.
ALLOWANCE FOR LAND AND BUILDING                                $   4500.


                   *LOW NOISE RECEIVER*

EQUIVALENT INPUT NOISE TEMPERATURE                             350 DEG K
PRE-AMP CAPITAL COST (WITH VOLUME DISCOUNT)                    $   1322.
     (BASED ON NON-DISCOUNTED, SINGLE ITEM COST OF  $   2500.)
INSTALLATION COST                                              $    250.
ANNUAL OPERATIONS AND MAINTENANCE COST                         $    375.
MISCELLANEOUS COSTS                                            $    500.


                       (CONTINUED)
```

```
                     ***SMALL STATION, CONTINUED***

               *POWER AMPLIFIERS AND CHANNEL CAPACITY*

RATED OUTPUT POWER OF INITIAL POWER AMPLIFIER                          5 W
  (OF STATIONS BEGINNING SERVICE IN YEAR ONE)
CAPITAL COST (WITH VOLUME DISCOUNT)                               $  2379.
     (BASED ON NON-DISCOUNTED, SINGLE ITEM COST OF  $   4500.)
INSTALLATION COST                                                 $   450.
ANNUAL OPERATIONS AND MAINTENANCE COST                            $   450.
MISCELLANEOUS COSTS                                               $   450.


     THE FOLLOWING TABLE SHOWS THE NUMBER OF NEW STATIONS THAT BEGIN
SERVICE AT THE FIRST OF YEAR U OF THE STUDY PERIOD, THE NUMBER OF
CHANNELS REQUIRED AT THE FIRST OF YEAR T OF THE STUDY BY A STATION
THAT BEGINS SERVICE AT THE FIRST OF YEAR U, AND, WITH AN ASTERISK, THE
SATURATED OUTPUT POWER RATING OF THE POWER AMPLIFIER REQUIRED TO HANDLE
THE ASSOCIATED NUMBER OF CHANNELS

YEAR U:       1       2       3       4       5       6       7       8
STNS
 ADDED:     200     200     200     200     200       0       0       0

YR T=  1      3       0       0       0       0       0       0       0
             5*      0*      0*      0*      0*      0*      0*      0*
       2      4       3       0       0       0       0       0       0
             5*      5*      0*      0*      0*      0*      0*      0*
       3      4       4       3       0       0       0       0       0
             5*      5*      5*      0*      0*      0*      0*      0*
       4      4       4       4       3       0       0       0       0
             5*      5*      5*      5*      0*      0*      0*      0*
       5      4       4       4       4       3       0       0       0
             5*      5*      5*      5*      5*      0*      0*      0*
       6      4       4       4       4       4       0       0       0
             5*      5*      5*      5*      5*      0*      0*      0*
       7      5       4       4       4       4       0       0       0
             5*      5*      5*      5*      5*      0*      0*      0*
       8      5       5       4       4       4       0       0       0
             5*      5*      5*      5*      5*      0*      0*      0*
       9      5       5       5       4       4       0       0       0
             5*      5*      5*      5*      5*      0*      0*      0*
      10      5       5       5       5       4       0       0       0
             5*      5*      5*      5*      5*      0*      0*      0*
      11      6       5       5       5       5       0       0       0
            10*      5*      5*      5*      5*      0*      0*      0*
      12      6       6       5       5       5       0       0       0
            10*     10*      5*      5*      5*      0*      0*      0*
      13      6       6       6       5       5       0       0       0
            10*     10*     10*      5*      5*      0*      0*      0*
      14      7       6       6       6       5       0       0       0
            10*     10*     10*     10*      5*      0*      0*      0*
      15      7       7       6       6       6       0       0       0
            10*     10*     10*     10*     10*      0*      0*      0*
```

```
                    ***LARGE STATION DATA SHEET***

               *CIRCUIT DEMAND AND STATION COST FIGURES*

THE DEMAND OFFERED TO A LARGE STATION FOR SERVICE        40.000 ERLANGS
  WITH ALL OTHER LARGE STATIONS DURING THE FIRST YEAR
  THE STATION IS IN OPERATION

THE PERCENT INCREASE IN DEMAND OFFERED TO A LARGE STATION FOR SERVICE
TO ALL OTHER LARGE STATIONS DURING EACH SUCCEEDING ONE-YEAR PERIOD OF
ITS SERVICE LIFE (FROM LEFT TO RIGHT, BEGINNING WITH THE FIRST YEAR THE
STATION IS IN OPERATION):
     11% 11% 11% 11% 11% 11% 11% 11% 11% 11% 11% 11% 11% 11% 11%

THE DEMAND OFFERED TO A LARGE STATION FOR SERVICE WITH ALL SMALL STA-
TIONS CAN NOT BE INDEPENDENTLY SPECIFIED.  IT IS CALCULATED SO AS TO BE
COMPATIBLE WITH THE DEMAND OFFERED TO SMALL STATIONS FOR SERVICE WITH
LARGE STATIONS.


THE NUMBER OF NEW STATIONS THAT BEGIN SERVICE IN EACH SUCCEEDING YEAR OF
THE STUDY PERIOD (FROM LEFT TO RIGHT, BEGINNING WITH YEAR 1):
       2    2    2    2    2    0    0    0    0    0    0    0    0    0    0

INITIAL CAPITAL COST PER STATION                                $  82400.
INITIAL INSTALLATION COST PER STATION                           $  10200.
INITIAL MISCELLANEOUS COST PER STATION                          $  12700.
INITIAL INSTALLED COST PER STATION                              $ 105300.


                              *ANTENNA*
DIAMETER                                                          20 FT
CAPITAL COST (WITH VOLUME DISCOUNT)                             $  29440.
     (BASED ON NON-DISCOUNTED, SINGLE ITEM COST OF   $  32000.)
INSTALLATION COST                                               $   6400.
ANNUAL OPERATIONS AND MAINTENANCE COST                          $   5760.
MISCELLANEOUS COSTS                                             $   6400.
ALLOWANCE FOR LAND AND BUILDING                                 $  18000.


                        *LOW NOISE RECEIVER*

EQUIVALENT INPUT NOISE TEMPERATURE                                97 DEG K
PRE-AMP CAPITAL COST (WITH VOLUME DISCOUNT)                     $  23000.
     (BASED ON NON-DISCOUNTED, SINGLE ITEM COST OF   $  25000.)
INSTALLATION COST                                               $   2500.
ANNUAL OPERATIONS AND MAINTENANCE COST                          $   6250.
MISCELLANEOUS COSTS                                             $   5000.


                             (CONTINUED)
                    ***LARGE STATION, CONTINUED***

               *POWER AMPLIFIERS AND CHANNEL CAPACITY*

RATED OUTPUT POWER OF INITIAL POWER AMPLIFIER                      100 W
  (OF STATIONS BEGINNING SERVICE IN YEAR ONE)
CAPITAL COST (WITH VOLUME DISCOUNT)                            $  11960.
     (BASED ON NON-DISCOUNTED, SINGLE ITEM COST OF  $  13000.)
INSTALLATION COST                                              $   1300.
ANNUAL OPERATIONS AND MAINTENANCE COST                         $   1300.
MISCELLANEOUS COSTS                                            $   1300.


     THE FOLLOWING TABLE SHOWS THE NUMBER OF NEW STATIONS THAT BEGIN
SERVICE AT THE FIRST OF YEAR U OF THE STUDY PERIOD, THE NUMBER OF
CHANNELS REQUIRED AT THE FIRST OF YEAR T OF THE STUDY BY A STATION
THAT BEGINS SERVICE AT THE FIRST OF YEAR U, AND, WITH AN ASTERISK, THE
SATURATED OUTPUT POWER RATING OF THE POWER AMPLIFIER REQUIRED TO HANDLE
THE ASSOCIATED NUMBER OF CHANNELS

YEAR U:       1       2       3       4       5       6       7       8
STNS
 ADDED:       2       2       2       2       2       0       0       0

YR T= 1     105       0       0       0       0       0       0       0
           100*      0*      0*      0*      0*      0*      0*      0*
      2     122      88       0       0       0       0       0       0
           100*    100*      0*      0*      0*      0*      0*      0*
      3     139     104      82       0       0       0       0       0
           100*    100*    100*      0*      0*      0*      0*      0*
      4     155     119      97      79       0       0       0       0
           300*    100*    100*    100*      0*      0*      0*      0*
      5     167     130     107      89      73       0       0       0
           300*    100*    100*    100*    100*      0*      0*      0*
      6     181     143     119     100      84       0       0       0
           300*    100*    100*    100*    100*      0*      0*      0*
      7     196     158     133     113      96       0       0       0
           300*    300*    100*    100*    100*      0*      0*      0*
      8     213     174     148     127     109       0       0       0
           300*    300*    300*    100*    100*      0*      0*      0*
      9     232     191     164     142     123       0       0       0
           300*    300*    300*    100*    100*      0*      0*      0*
     10     253     211     183     160     140       0       0       0
           300*    300*    300*    300*    100*      0*      0*      0*
     11     277     233     204     180     159       0       0       0
           300*    300*    300*    300*    300*      0*      0*      0*
     12     303     258     227     202     179       0       0       0
           300*    300*    300*    300*    300*      0*      0*      0*
     13     333     286     253     226     202       0       0       0
           300*    300*    300*    300*    300*      0*      0*      0*
     14     366     317     282     253     228       0       0       0
           300*    300*    300*    300*    300*      0*      0*      0*
     15     403     351     314     284     257       0       0       0
           300*    300*    300*    300*    300*      0*      0*      0*
```

```
                      ***SATELLITE SEGMENT DATA SHEET***


                        *EQUIPMENT SPECIFICATIONS*

SATELLITE LIFETIME                                                   7 YRS
ANTENNA BEAMWIDTH                                            7.0 X  5.0 DEG
RECEIVER EQUIVALENT INPUT NOISE TEMPERATURE                     1200 DEG K
RECEIVE G/T, AT BEAM CENTER                                        -2.4 DB
TOTAL RATED SATURATED OUTPUT POWER, PER SATELLITE                    120 W

TRANSPONDER GAINS (THE GAIN OF A TRANSPONDER IS DEFINED HERE AS THE
RATIO OF THE POWER PER CARRIER AT THE INPUT TO THE TRANSMIT ANTENNA
TO THAT AT THE OUTPUT OF THE RECEIVE ANTENNA):
  TRANSPONDERS FOR LARGE STATION-TO-LARGE STATION CARRIERS     115.2 DB
  TRANSPONDERS FOR SMALL STATION-TO-LARGE STATION CARRIERS     113.4 DB
  TRANSPONDERS FOR LARGE STATION-TO-SMALL STATION CARRIERS     124.2 DB
  TRANSPONDERS FOR SMALL STATION-TO-SMALL STATION CARRIERS     122.4 DB

IN-ORBIT RATED SATURATED OUTPUT POWER REQUIREMENT, IN WATTS, FOR EACH
YEAR OF THE STUDY PERIOD (FROM LEFT TO RIGHT, BEGINNING WITH YEAR 1)
  TOTAL     44   49   53   60   65   68   72   76   80   85   90   96  102  110  118
 L-TO-L      0    1    1    2    4    4    5    6    6    7    8    9   10   11   13
 L-TO-S      5    8   10   13   15   16   18   20   22   25   27   31   34   38   42
 S-TO-S      2    3    4    7    8    9   11   12   13   14   15   17   19   21   23
 S-TO-L      0    0    0    0    1    1    1    1    1    2    2    2    2    3    3
     TV     36   36   36   36   36   36   36   36   36   36   36   36   36   36   36

THE DISCOUNTED NUMBER OF WATT-YEARS OF EACH OF THE ABOVE POWER REQUIRE-
MENTS (NORMALIZED TO  575, THE NUMBER CORRESPONDING TO THE TOTAL POWER
REQUIREMENT):
          TOTAL=1.000           L-TO-L=0.129           L-TO-S=0.014
             TV=0.538           S-TO-S=0.074           S-TO-L=0.244

REQUIRED SATELLITE LAUNCHES, IN UNITS, VERSUS TIME (FROM LEFT TO RIGHT,
BEGINNING WITH YEAR 1 OF THE STUDY PERIOD)
             2    0    0    0    0    0    0    2    0    0    0    0    0    0    2


                                 *COSTS*

SATELLITE DEVELOPMENT COST                                          8.0 $M
IN-ORBIT COST PER SATELLITE (NOT INCL. DEVELOPMENT)                16.0 $M
TOTAL PRESENT WORTH OF SATELLITE SEGMENT                           71.3 $M
```

```
 ** LINK CALCULATIONS FOR SMALL STATION-TO-SMALL STATION CONNECTIONS **

                              *UP LINK*
POWER AT ANTENNA INPUT                           -6.9 DBW
ANTENNA GAIN                                     42.6 DB
POINTING ERROR AND ATMOSPHERIC ABSORPTION         0.5 DB
RAIN LOSS (SEE FOOTNOTE).                         1.7 DB
PATH LOSS                                       200.1 DB
SATELLITE G/T                                    -2.4 DB
LOSS FOR RECEPTION AT 3-DB BEAM EDGE              3.0 DB
UP-LINK C/T                                    -171.9 DB
NOISE BANDWIDTH (21.0 KHZ)                       43.2 DB
BOLTZMANN'S CONSTANT                           -228.6 DBW
UP-LINK C/N                                                   13.5 DB
  (BASEBAND NOISE FROM UP-LINK THERMAL NOISE:  25329 PWPO)

         *CARRIER-TO-SATELLITE INTERMODULATION NOISE RATIO*
C/I (WITH  6 DB OF OUTPUT BACKOFF)               17.0 DB
CARRIER ATTENUATION DUE TO UP-LINK RAIN LOSS      1.7 DB
C/I                                                           15.3 DB
  (BASEBAND NOISE FROM INTERMODULATION DISTORTION:  16511 PWPO)

                             *DOWN LINK*
POWER AT ANTENNA INPUT                          -15.2 DBW
ANTENNA GAIN                                     28.4 DB
LOSS FOR TRANSMISSION AT 3-DB BEAM EDGE           3.0 DB
PATH LOSS                                       196.6 DB
RAIN LOSS (SEE FOOTNOTE).                         0.0 DB
ATTENUATION FROM UP-LINK RAIN LOSS                1.7 DB
POINTING ERROR AND ATMOSPHERIC ABSORPTION         0.5 DB
EARTH-STATION G/T                                13.7 DB
DEGRADATION IN G/T DUE TO DOWN-LINK RAIN LOSS     0.0 DB
DOWN-LINK C/T                                  -174.9 DB
NOISE BANDWIDTH (21.0 KHZ)                       43.2 DB
BOLTZMANN'S CONSTANT                           -228.6 DBW
DOWN-LINK C/N                                                 10.4 DB
  (BASEBAND NOISE FROM DOWN-LINK THERMAL NOISE:  50658 PWPO)

                              *SYSTEM*
SYSTEM C/N (COMBINING THE ABOVE RESULTS)                       7.5 DB
THE QUALITY OF THE CHANNEL IS SUCH THAT TOTAL BASEBAND NOISE,
IN THE WORST CASE, WILL NOT EXCEED                          99998 PWPO
 (THE SUM OF THE CONTRIBUTIONS NOTED ABOVE AND AN ALLOW-
ANCE OF  7500 PWPO FROM ALL OTHER NOISE SOURCES.)



FOOTNOTE:  IT IS ASSUMED THAT RAIN LOSSES WILL NOT OCCUR SIMULTANEOUSLY
ON BOTH THE UP LINK AND THE DOWN LINK.  BASED ON MAXIMUM LOSSES (NOT
EXCEEDED 99% OF THE TIME) OF 1.70 DB AND 1.00 DB, RESPECTIVELY, THE
PROGRAM HAS DETERMINED THAT RAIN LOSS IN THE  UP  LINK IS THE MORE DET-
RIMENTAL TO OVERALL QUALITY.  (OF COURSE, WHEN RAIN LOSS OCCURS IN THE
UP LINK, THIS SAME DIMINUATION IN CARRIER POWER CARRIES OVER, THROUGH A
LINEAR TRANSPONDER, TO THE DOWN LINK AS WELL.)
```

```
** LINK CALCULATIONS FOR SMALL STATION-TO-LARGE STATION CONNECTIONS**

                              *UP LINK*
POWER AT ANTENNA INPUT                                   -7.6 DBW
ANTENNA GAIN                                             42.6 DB
POINTING ERROR AND ATMOSPHERIC ABSORPTION                 0.5 DB
RAIN LOSS (SEE FOOTNOTE).                                 0.0 DB
PATH LOSS                                               200.1 DB
SATELLITE G/T                                            -2.4 DB
LOSS FOR RECEPTION AT 3-DB BEAM EDGE                      3.0 DB
UP-LINK C/T                                            -170.9 DB
NOISE BANDWIDTH (21.0 KHZ)                               43.2 DB
BOLTZMANN'S CONSTANT                                   -228.6 DBW
UP-LINK C/N                                                              14.5 DB
  (BASEBAND NOISE FROM UP-LINK THERMAL NOISE:  20093 PWPO)

           *CARRIER-TO-SATELLITE INTERMODULATION NOISE RATIO*
C/I (WITH  6 DB OF OUTPUT BACKOFF)                       17.0 DB
CARRIER ATTENUATION DUE TO UP-LINK RAIN LOSS              0.0 DB
C/I                                                                      17.0 DB
  (BASEBAND NOISE FROM INTERMODULATION DISTORTION:  11167 PWPO)

                              *DOWN LINK*
POWER AT ANTENNA INPUT                                  -26.7 DBW
ANTENNA GAIN                                             28.4 DB
LOSS FOR TRANSMISSION AT 3-DB BEAM EDGE                   3.0 DB
PATH LOSS                                               196.6 DB
RAIN LOSS (SEE FOOTNOTE).                                 1.0 DB
ATTENUATION FROM UP-LINK RAIN LOSS                        0.0 DB
POINTING ERROR AND ATMOSPHERIC ABSORPTION                 0.5 DB
EARTH-STATION G/T                                        25.7 DB
DEGRADATION IN G/T DUE TO DOWN-LINK RAIN LOSS             2.1 DB
DOWN-LINK C/T                                          -175.8 DB
NOISE BANDWIDTH (21.0 KHZ)                               43.2 DB
BOLTZMANN'S CONSTANT                                   -228.6 DBW
DOWN-LINK C/N                                                             9.6 DB
  (BASEBAND NOISE FROM DOWN-LINK THERMAL NOISE:  61235 PWPO)

                              *SYSTEM*
SYSTEM C/N (COMBINING THE ABOVE RESULTS)                                  7.5 DB
THE QUALITY OF THE CHANNEL IS SUCH THAT TOTAL BASEBAND NOISE,
IN THE WORST CASE, WILL NOT EXCEED                                    99995 PWPO
 (THE SUM OF THE CONTRIBUTIONS NOTED ABOVE AND AN ALLOW-
ANCE OF  7500 PWPO FROM ALL OTHER NOISE SOURCES.)



FOOTNOTE:  IT IS ASSUMED THAT RAIN LOSSES WILL NOT OCCUR SIMULTANEOUSLY
ON BOTH THE UP LINK AND THE DOWN LINK.  BASED ON MAXIMUM LOSSES (NOT
EXCEEDED 99% OF THE TIME) OF 1.70 DB AND 1.00 DB, RESPECTIVELY, THE
PROGRAM HAS DETERMINED THAT RAIN LOSS IN THE DOWN LINK IS THE MORE DET-
RIMENTAL TO OVERALL QUALITY.  (OF COURSE, WHEN RAIN LOSS OCCURS IN THE
UP LINK, THIS SAME DIMINUATION IN CARRIER POWER CARRIES OVER, THROUGH A
LINEAR TRANSPONDER, TO THE DOWN LINK AS WELL.)
```

```
***LINK CALCULATIONS FOR LARGE STATION-TO-LARGE STATION CONNECTIONS***


                          *UP LINK*
POWER AT ANTENNA INPUT                            -11.3 DBW
ANTENNA GAIN                                       49.1 DB
POINTING ERROR AND ATMOSPHERIC ABSORPTION           0.5 DB
RAIN LOSS (SEE FOOTNOTE),                           1.7 DB
PATH LOSS                                         200.1 DB
SATELLITE G/T                                      -2.4 DB
LOSS FOR RECEPTION AT 3-DB BEAM EDGE                3.0 DB
UP-LINK C/T                                      -170.0 DB
NOISE BANDWIDTH (38.0 KHZ)                         45.8 DB
BOLTZMANN'S CONSTANT                             -228.6 DBW
UP-LINK C/N                                                       12.8 DB
  (BASEBAND NOISE FROM UP-LINK THERMAL NOISE:    2924 PWPO)

          *CARRIER-TO-SATELLITE INTERMODULATION NOISE RATIO*
C/I (WITH  6 DB OF OUTPUT BACKOFF)                 17.0 DB
CARRIER ATTENUATION DUE TO UP-LINK RAIN LOSS        1.7 DB
C/I                                                               15.3 DB
  (BASEBAND NOISE FROM INTERMODULATION DISTORTION:   1649 PWPO)

                         *DOWN LINK*
POWER AT ANTENNA INPUT                            -22.3 DBW
ANTENNA GAIN                                       28.4 DB
LOSS FOR TRANSMISSION AT 3-DB BEAM EDGE             3.0 DB
PATH LOSS                                         196.6 DB
RAIN LOSS (SEE FOOTNOTE),                           0.0 DB
ATTENUATION FROM UP-LINK RAIN LOSS                  1.7 DB
POINTING ERROR AND ATMOSPHERIC ABSORPTION           0.5 DB
EARTH-STATION G/T                                  25.7 DB
DEGRADATION IN G/T DUE TO DOWN-LINK RAIN LOSS       0.0 DB
DOWN-LINK C/T                                    -170.0 DB
NOISE BANDWIDTH (38.0 KHZ)                         45.8 DB
BOLTZMANN'S CONSTANT                             -228.6 DBW
DOWN-LINK C/N                                                     12.8 DB
  (BASEBAND NOISE FROM DOWN-LINK THERMAL NOISE:   2924 PWPO)

                          *SYSTEM*
SYSTEM C/N (COMBINING THE ABOVE RESULTS)                           7.5 DB
THE QUALITY OF THE CHANNEL IS SUCH THAT TOTAL BASEBAND NOISE,
IN THE WORST CASE, WILL NOT EXCEED                              9997 PWPO
 (THE SUM OF THE CONTRIBUTIONS NOTED ABOVE AND AN ALLOW-
ANCE OF  2500 PWPO FROM ALL OTHER NOISE SOURCES.)



FOOTNOTE:  IT IS ASSUMED THAT RAIN LOSSES WILL NOT OCCUR SIMULTANEOUSLY
ON BOTH THE UP LINK AND THE DOWN LINK.  BASED ON MAXIMUM LOSSES (NOT
EXCEEDED 99% OF THE TIME) OF 1.70 DB AND 1.00 DB, RESPECTIVELY, THE
PROGRAM HAS DETERMINED THAT RAIN LOSS IN THE  UP  LINK IS THE MORE DET-
RIMENTAL TO OVERALL QUALITY.  (OF COURSE, WHEN RAIN LOSS OCCURS IN THE
UP LINK, THIS SAME DIMINUATION IN CARRIER POWER CARRIES OVER, THROUGH A
LINEAR TRANSPONDER, TO THE DOWN LINK AS WELL.)
```

```
  ***LINK CALCULATIONS FOR LARGE STATION-TO-SMALL STATION CONNECTIONS***


                            *UP LINK*
POWER AT ANTENNA INPUT                                -12.0 DBW
ANTENNA GAIN                                           49.1 DB
POINTING ERROR AND ATMOSPHERIC ABSORPTION               0.5 DB
RAIN LOSS (SEE FOOTNOTE),                               1.7 DB
PATH LOSS                                             200.1 DB
SATELLITE G/T                                          -2.4 DB
LOSS FOR RECEPTION AT 3-DB BEAM EDGE                    3.0 DB
UP-LINK C/T                                          -170.7 DB
NOISE BANDWIDTH (21.0 KHZ)                             43.2 DB
BOLTZMANN'S CONSTANT                                 -228.6 DBW
UP-LINK C/N                                                          14.7 DB
  (BASEBAND NOISE FROM UP-LINK THERMAL NOISE:  18996 PWPO)

          *CARRIER-TO-SATELLITE INTERMODULATION NOISE RATIO*
C/I (WITH  6 DB OF OUTPUT BACKOFF)                     17.0 DB
CARRIER ATTENUATION DUE TO UP-LINK RAIN LOSS            1.7 DB
C/I                                                                  15.3 DB
  (BASEBAND NOISE FROM INTERMODULATION DISTORTION:  16511 PWPO)

                           *DOWN LINK*
POWER AT ANTENNA INPUT                                -15.7 DBW
ANTENNA GAIN                                           28.4 DB
LOSS FOR TRANSMISSION AT 3-DB BEAM EDGE                 3.0 DB
PATH LOSS                                             196.6 DB
RAIN LOSS (SEE FOOTNOTE),                               0.0 DB
ATTENUATION FROM UP-LINK RAIN LOSS                      1.7 DB
POINTING ERROR AND ATMOSPHERIC ABSORPTION               0.5 DB
EARTH-STATION G/T                                      13.7 DB
DEGRADATION IN G/T DUE TO DOWN-LINK RAIN LOSS           0.0 DB
DOWN-LINK C/T                                        -175.5 DB
NOISE BANDWIDTH (21.0 KHZ)                             43.2 DB
BOLTZMANN'S CONSTANT                                 -228.6 DBW
DOWN-LINK C/N                                                         9.9 DB
  (BASEBAND NOISE FROM DOWN-LINK THERMAL NOISE:  56988 PWPO)

                            *SYSTEM*
SYSTEM C/N (COMBINING THE ABOVE RESULTS)                              7.5 DB
THE QUALITY OF THE CHANNEL IS SUCH THAT TOTAL BASEBAND NOISE,
IN THE WORST CASE, WILL NOT EXCEED                                 99995 PWPO
 (THE SUM OF THE CONTRIBUTIONS NOTED ABOVE AND AN ALLOW-
ANCE OF  7500 PWPO FROM ALL OTHER NOISE SOURCES.)



FOOTNOTE:  IT IS ASSUMED THAT RAIN LOSSES WILL NOT OCCUR SIMULTANEOUSLY
ON BOTH THE UP LINK AND THE DOWN LINK.  BASED ON MAXIMUM LOSSES (NOT
EXCEEDED 99% OF THE TIME) OF 1.70 DB AND 1.00 DB, RESPECTIVELY, THE
PROGRAM HAS DETERMINED THAT RAIN LOSS IN THE  UP  LINK IS THE MORE DET-
RIMENTAL TO OVERALL QUALITY.  (OF COURSE, WHEN RAIN LOSS OCCURS IN THE
UP LINK, THIS SAME DIMINUATION IN CARRIER POWER CARRIES OVER, THROUGH A
LINEAR TRANSPONDER, TO THE DOWN LINK AS WELL.)
```

--Total system cost (w/o auxiliary st'ns)
--1st loop variable
--2nd loop variable
--3rd loop variable
--4th loop variable
--5th loop variable
--6th loop variable
--st'n antenna dia.
--st'n noise temp.
--total sat. segment cost
--total power amp. cost for host st'ns
--output pwr/ch for host-to-host connection (up-link)
--output pwr/ch for down-link h-to-h
--h-to-h xpndr gain
--output pwr/ch for h-to-aux. connection (up-link)
--output pwr/ch for down-link h-to-aux.
--h-to-aux. xpndr gain

```
   TCOST   IPC  IX  BD  NX NDA NXA  AD    T     SCOST    PCOST    PE     PS   GTR    PEA     PSA  GTRA  PXII  MW    PWA IFX   IFXA STM
  1.19E 02  9.  1.  6. 11.  6. 10. 10.  350.    91.544   18.214  733.6  107.1 174.2  611.4    3.0 109.5  5.0  0.0   0.0  0.    0.   2.
  1.19E 02  9.  2.  6. 13.  6. 10. 12.  504.    88.994   18.214  849.1   89.2 171.2  424.6    3.0 109.5  5.0  0.0   0.0  0.    0.   2.
  1.74E 02  9.  3.  6. 13.  6. 10. 20. 1541.    88.994   13.135  277.9   89.7 171.2  138.9    3.0 109.5  5.0  0.0   0.0  0.    0.   2.
  1.14E 02 10.  1.  6. 11.  6.  3. 12.  401.    84.609   15.867  509.5   85.1 123.2  305.7    4.0 112.2  4.0  0.0   0.0  0.    0.   2.
  1.16E 02 11.  1.  6. 10.  6. 10. 15.  547.    80.585   13.135  247.0   75.1 123.5  247.0    3.0 109.5  4.0  0.0   0.0  0.    0.   2.
  1.64E 02 11.  2.  6. 13.  6. 10. 20.  572.    78.842   13.135  277.9   56.3 119.2  138.9    3.0 109.5  4.0  0.0   0.0  0.    0.   2.
* 1.13E 02 13.  1.  6.  9.  6.  9. 15.  345.    75.819   12.460  197.6   56.8 123.2  197.6    3.6 111.2  3.0  0.0   0.0  0.    0.   2.
  1.59E 02 13.  2.  6.  9.  6.  9. 20.  613.    75.819   10.088  111.2   56.8 123.2  111.2    3.6 111.2  3.0  0.0   0.0  0.    0.   2.
  1.23E 02 14.  1.  6.  9.  6.  8. 12.  159.    73.320   15.181  339.6   45.1 122.2  305.7    4.0 112.2  3.0  0.0   0.0  0.    0.   2.
```

Key parameters of the minimum-cost system configurations that obtain when the small-station G/T is varied from its optimum value, as shown by the asterisk.

```
   TCOST   IPC  IX  BO  NX NDA NXA  AD    T     SCOST    PCOST    PE     PS   GTR    PEA     PSA  GTRA  PXII  MW    PWA IFX   IFXA STM
  7.96E 01 21.  1.  6. 12.  6. 15. 20.   97.    77.259    0.897  606.3   16.3 110.4  389.0   33.1 115.4  7.0  0.0   0.0  0.    0.   2.
  9.24E 01 21.  2.  6. 12.  6. 14. 42.  478.    77.259    0.588  137.5   16.3 110.4   75.6   34.1 116.2  7.0  0.0   0.0  0.    0.   2.
  7.97E 01 23.  1.  6. 11.  6. 13. 25.   96.    75.819    0.715  291.0   11.6 110.2  177.8   35.5 117.2  6.0  0.0   0.0  0.    0.   2.
  7.91E 01 23.  2.  6. 11.  6. 13. 32.  157.    75.819    0.623  177.6   11.6 110.2  108.6   35.5 117.2  6.0  0.0   0.0  0.    0.   2.
  7.93E 01 24.  1.  6. 12.  6. 16. 25.   76.    74.510    0.851  420.2    8.9 107.4  284.6   32.5 114.8  7.0  1.0   0.0  0.    0.   2.
  1.16E 02 24.  2.  6. 10.  6. 12. 85.  558.    75.819    0.280   19.2   10.2 110.5   11.3   37.9 118.4  7.0  0.0   0.0  0.    0.   2.
* 7.71E 01 25.  1.  6. 16.  6. 14. 32.   99.    74.510    0.609  149.0    8.1 [illegible] 130.3   34.1 116.2  6.0  0.0   0.0  0.    0.   2.
  8.39E 01 25.  2.  6. 16.  6. 14. 42.  170.    74.510    0.485   85.9    8.1 109.5   75.6   34.1 116.2  6.0  0.0   0.0  0.    0.   2.
  7.89E 01 27.  1.  6.  7.  6. 13. 32.   62.    74.510    0.558   93.7    7.7 111.0  108.6   35.5 117.2  6.0  0.0   0.0  0.    0.   2.
  9.01E 01 27.  2.  6.  9.  6. 12. 42.  107.    74.510    0.442   68.7    6.2 109.2   50.4   37.9 118.4  6.0  0.0   0.0  0.    0.   2.
```

Key parameters of the minimum-cost system configurations that obtain when the large-station G/T is varied from its optimum value, as shown by the asterisk.

ATTACHMENT XI.5

The Point Reyes Station Tests

The Point Reyes station was designed to work with the Anik II satellite, the satellite characteristics, ground station characteristics, and test results are given below.

a. Satellite Characteristics

The following characteristics were obtained from Don Weiss of Telesat Canada. We were referred to him by Barry Murphy of Telesat. The information was given in terms of power flux at the satellite necessary to saturate the output amplifiers, the saturation output of the amplifiers times the antenna gain (EIRP), and the gain characteristics of a typical amplifier. The information is unofficial, i.e, accurate but not legally binding, and should not be credited to Telesat.

The information given is for Anik II, the backup satellite. The saturation flux at the satellite varies with the channel used since antenna gain is a function of frequency. It is also a function of position of the stations in Alaska.

Saturation Flux for Anchorage

Channel 1	-81.5 dBW/M^2
Channel 5	-83 dBW/M^2
Channel 8	-82 dBW/M^2
Channel 12	-82 dBW/M^2

The saturation flux for the rest of Alaska except the Aleutian areas is no worse than 3 dB greater than the above figures.

These saturation fluxes will result in an Effective Isotropic Radiated Power (EIRP) in the direction of Anchorage as shown in the following table:

Saturated EIRP for Anchorage

Channel 1	33 dBW
Channel 2	34 dBW
Channel 6	34.5 dBW
Channel 7	33 dBW
Channel 11	33.5 dBW
Channel 12	34 dBW

The satellite transponder behavior below saturation is described by the following table. This information is for a typical channel and may vary some from channel to channel.

Transponder Characteristics

Input Relative to Saturation Level	Output Relative to Saturation Level	Gain Relative to Saturation Gain
0 dB	0 dB	0 dB
-5 dB	-1 dB	+4 dB
-8 dB	-2.9 dB	+5.1 dB
-10 dB	-4.6 dB	+5.4 dB
-12 dB	-6.6 dB	+5.4 dB

The Satellite Transponder Gain in dBW/dBW/M^2 is found by dividing (subtracting in dB) the Saturation Flux from the Saturated EIRP for each transponder. The gain at 5 dB away from saturation is found by adding 5.4 dB to the saturated gain figures.

Satellite Transponder Gain Anchorage

	At Saturation	5 dB below Saturation
Channel 1	114.5 dBW/dBW/M^2	119.9 dBW/dBW/M^2
Channel 12	116.0 dBW/dBW/M^2	121.4 dBW/dBW/M^2

The Satellite Transponder Gain for the rest of Alaska except the Aleutian areas is no worse than 5 dB less than the above figures.

It should be noted that these figures are for a satellite slew angle of 1.37° West, the satellite pointing being set that far from the suborbit longitude of the satellite. Better Western-Alaska performance can be obtained with a larger slew angle. This would need to be investigated relative to Canadian customers on the East Coast and the impact on satellite operations.

The gain at Atka in the Aleutian Islands is about 3 to 5 dB worse than the rest of Alaska; however, this information is very approximate.

Negotiations, not yet completed, call for RCA to use transponder 12 and Amsat to use transponder 1.

b. Ground Station Characteristics

The communications services required between Alaskan medical centers and health aides in the villages are described below:

> At each village is a single voice channel transponder. The equipment is of the simplex variety (push to talk) and can monitor other calls through the satellite using the same satellite frequency. Its transmit and receive frequencies are fixed and can be changed only by a field modification. Power is from a 24 volt automobile battery recharged periodically by local electric generators.
>
> At each medical center is a voice transponder similar in every way to the village transponders except that it can be switched by mechanical switch to work on one to four satellite channels.
>
> Initially, all stations will use a single 24-hour/day simplex channel on Canada's Anik satellite. Routine traffic from different service areas would be assigned to different hours of the day. As requirements exceed one channel, additional channels would be added with different service areas being assigned to different channels.

> Each station is to be equipped with an emergency interrupt function. When the button is pushed a recognizable noise is to be heard on all receivers tuned to that channel even if some other station is transmitting at the same time. When the channel is cleared in response to this signal, an alarm will ring at the medical center.
>
> Under normal conditions, the circuit is to provide a toll quality service, TT/N of 40 dB or greater. Under worst case rain and pointing error the system is to maintain "intelligibility excellent" (13 to 16 dB SNR).

To meet these requirements, the station consists of a 30 watt amplifier, a 10 ft. diameter antenna and a preamplifier with a 4.5 dB noise figure. The channelizing equipment uses threshold extension and compandering to meet the performance requirement under normal conditions. The station is designed for a fixed transmit frequency at 6 GHz and receive frequency at 4 GHz. The station's 6 GHz transmit polarization is linear and parallel to the polarization; the 4 GHz polarization is linear and parallel to the equator.

The link calculations, Table 1, are based on a worst case satellite transponder gain (114.9 dBW/dBW/M^2).

Atka, on the Aleutian Islands offers a special problem. It is so far off the beam of the satellite that an added 4 to 5 dB loss will be incurred in a communication between Atka and a station in central Alaska. Detailed estimates are still to be done, but initial indications are that Atka could be served with a 15 ft. antenna at an added cost of $3,000 to $5,000.

For the test, transmit and receive frequencies were set so that the station operated in a simplex mode (it was set to receive its own transmissions through the satellite). A production model would be set for simplex operation for Alaskan health service uses and duplex for normal

Table 1

Station Link Calculation

The link performance calculations for an "optimum" station are performed below. The calculation uses Transponder 1 for all Alaska except the Aleutians. [114.9 DBW/DBW/M²]. Two conditions are estimated, one with no rain loss and station pointing error, the other with these losses.

LINK PARAMETERS

Uplink Frequency	6 GHz
Path Length to Satellite	41173 km
Downlink Frequency	4 GHz
Satellite G/T On-Axis	-7 dB/Deg K
Satellite Intermod Relative to EIRP	-15 dB
Satellite Transponder Gain	114.9 dB/dB/M²

LINK CALCULATIONS

	With Loss	Without Loss
Transmitter Power (30 watts)	14.8	14.8 dB
Station Antenna Diameter	10	10 ft.
Transmit Gain	43.0	43.0 dB
Transmit Line Loss	1.5	1.5 dB
Transmit Point Loss	.5	- dB
Uplink Rain Loss	.1	- dB
Flux at Satellite	-108.5	-107.0 dB/M²
C/kT Up	73.1	74.6 dB
EIRP from Satellite	6.4	7.9 dB
Rain/Atmosphere Loss Down	.7	- dB
Receive Pointing Loss	.3	- dB
Receive Line Loss	.8	.8 dB
Preamplifier Noise (TDA4.5BNF)	525	525 °K
System Noise Temp., Incl. Rain	615	570 °K
Receive Gain	39.5	39.5 dB
Receive G/T	11.6	11.8 dB/°K
C/kT Down	48.0	50.7 dB/Hz
RF Bandwidth	20	20 kHz
C/IM Noise Density	58	58 dB/Hz
C/kT Total	47.6	50.0 dB/Hz
RF Bandwidth	20	20 kHz
C/N Ratio in RF Bandwidth	4.6	7.0 dB
Audio Bandwidth	3.4	3.4 kHz
Approximate*Voice/Noise Ratio	12.3	45 to 50 dB

*Equivalent subjective signal to noise ratio of a compandered circuit with the above C/kT.

telephone uses. In the demonstration two push-to-talk microphone speaker sets were used to carry conversations through the satellite.

c. Installation

Records were kept of operations that would be needed in normal field installation. Ground preparation and setting of ground anchors to hold the wooden mounting beams require approximately one-half day. Assembly of the antenna and mounting it on the beams required three hours, (see Fig. 1). Installation of the electronics antenna pointing and final checkout required less than three hours. Ground preparation and installation of electronics depend on local conditions and on the building that will house the equipment.

The antenna was transported to the site in the back of a Volkswagen-type van, about half filling it. A gasoline-powered post hole digger was used to set the ground anchors. Only hand tools were used to assemble the antenna.

d. Performance

The link calculations (Table 1) were confirmed within approximately 1/2 dB on the uplink and 1 dB on the downlink by the end of the tests. During the check out periods several deviations from specifications were identified and corrected. These are discussed below in the section "Test Deviations."

At the nominal link performance levels, signal-to-noise measurements were made and tapes obtained through the satellite. The system uses compandoring, a technique to optimize link characteristics for the human voice and ear. The subjective performance of the link was equivalent to a test-tone-to-noise ratio of 45 to 50 dB, i.e., toll telephone

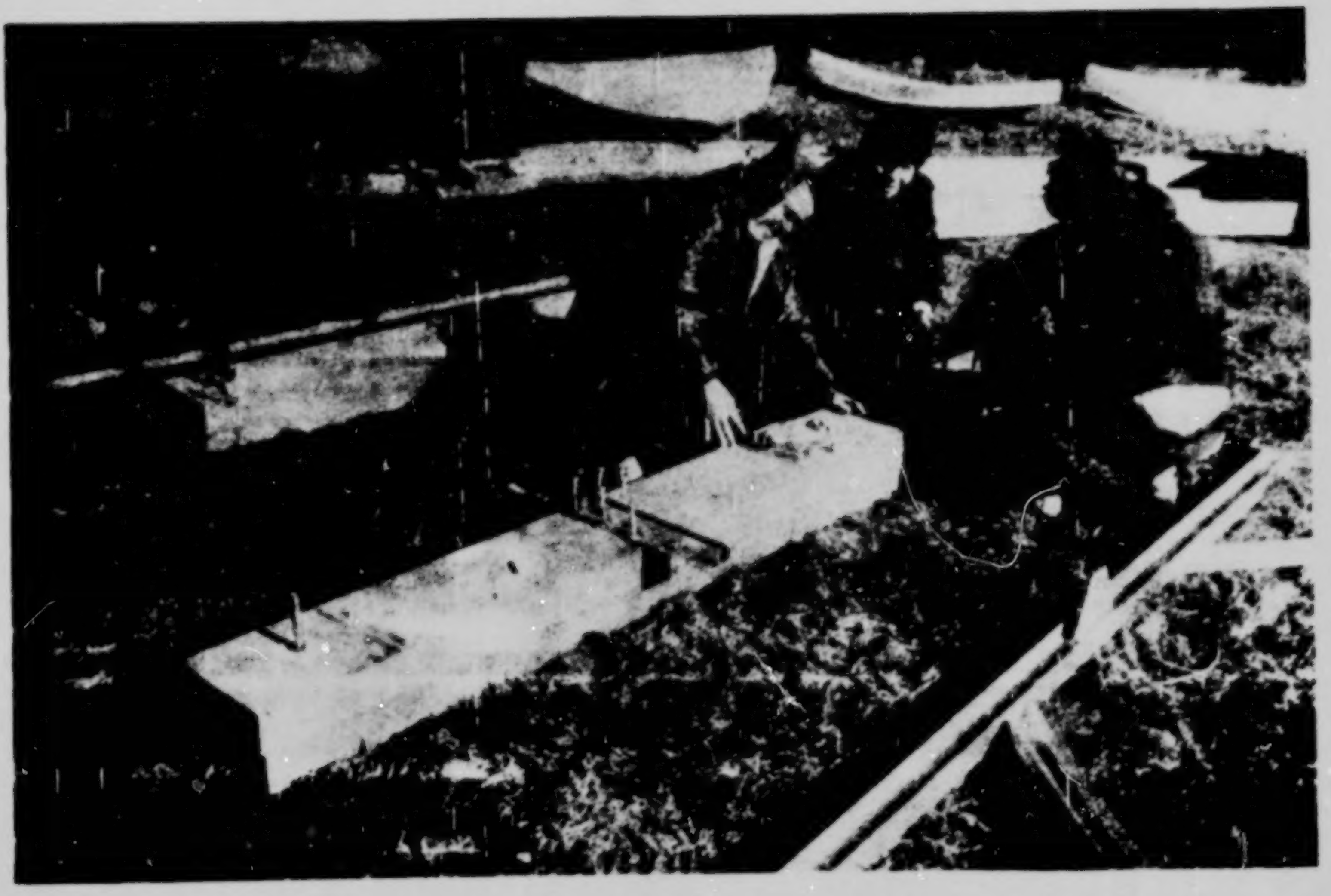

Figure 1 (a)

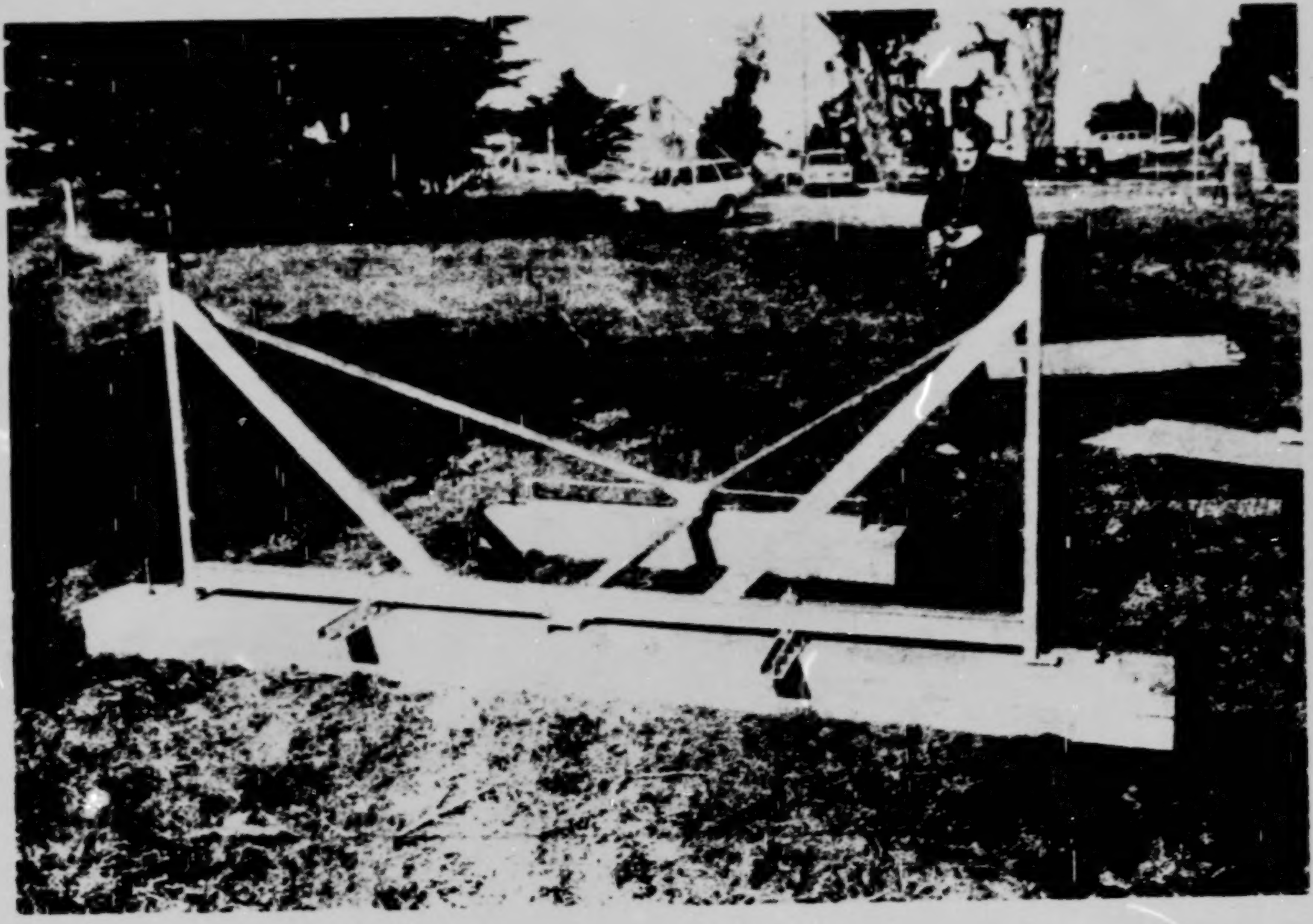

Figure 1 (b)

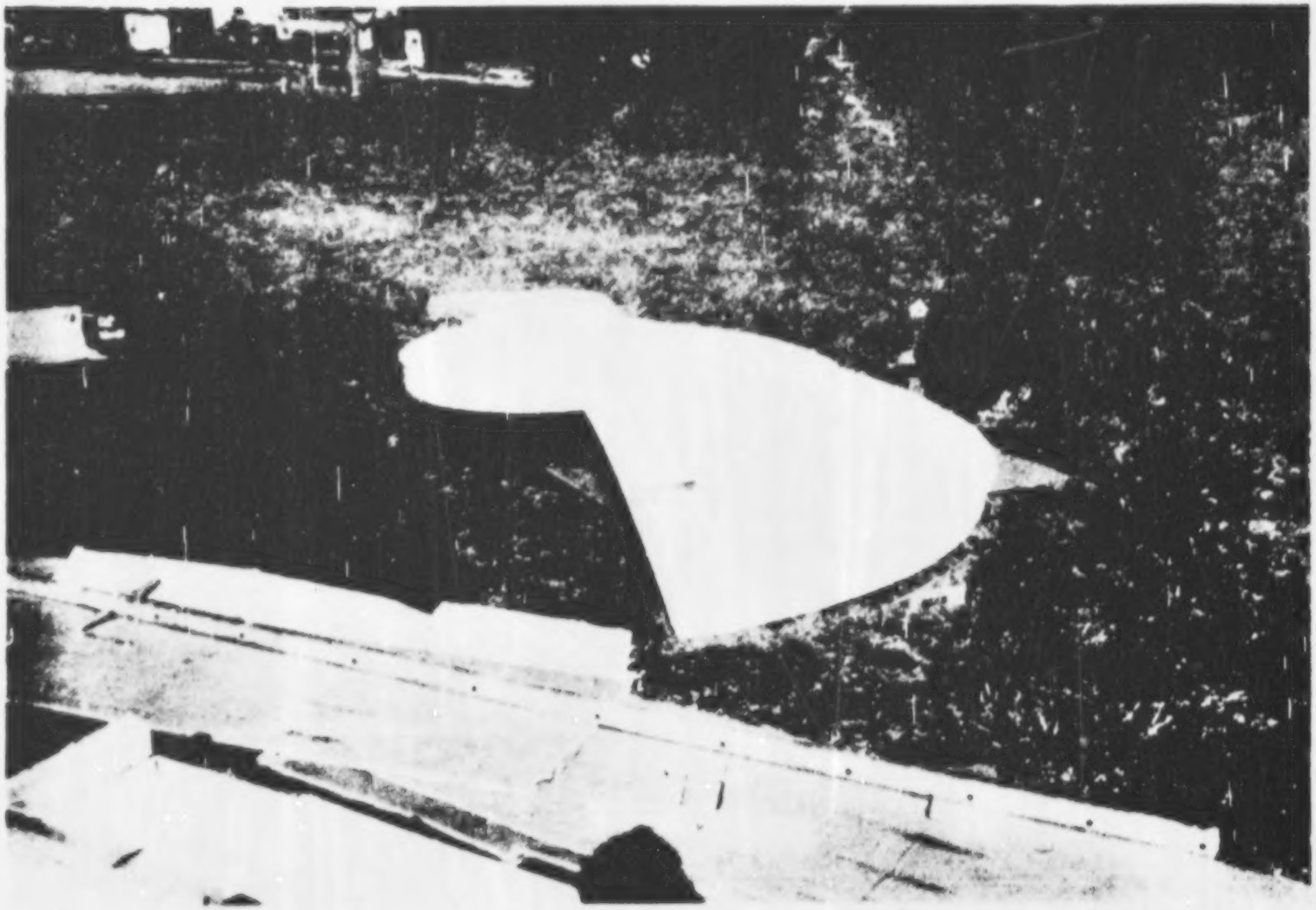

Figure 1 (c)

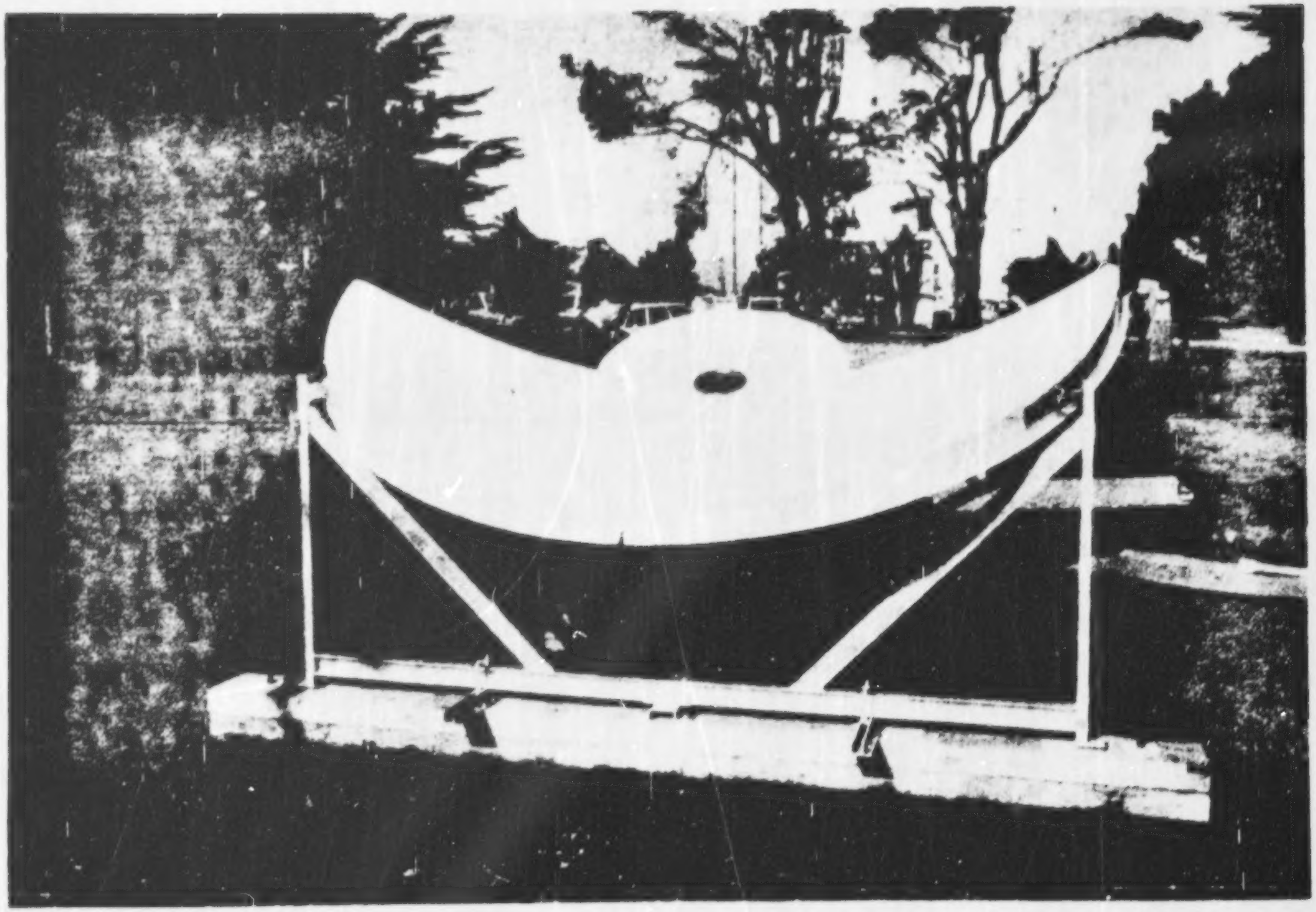

Figure 1 (d)

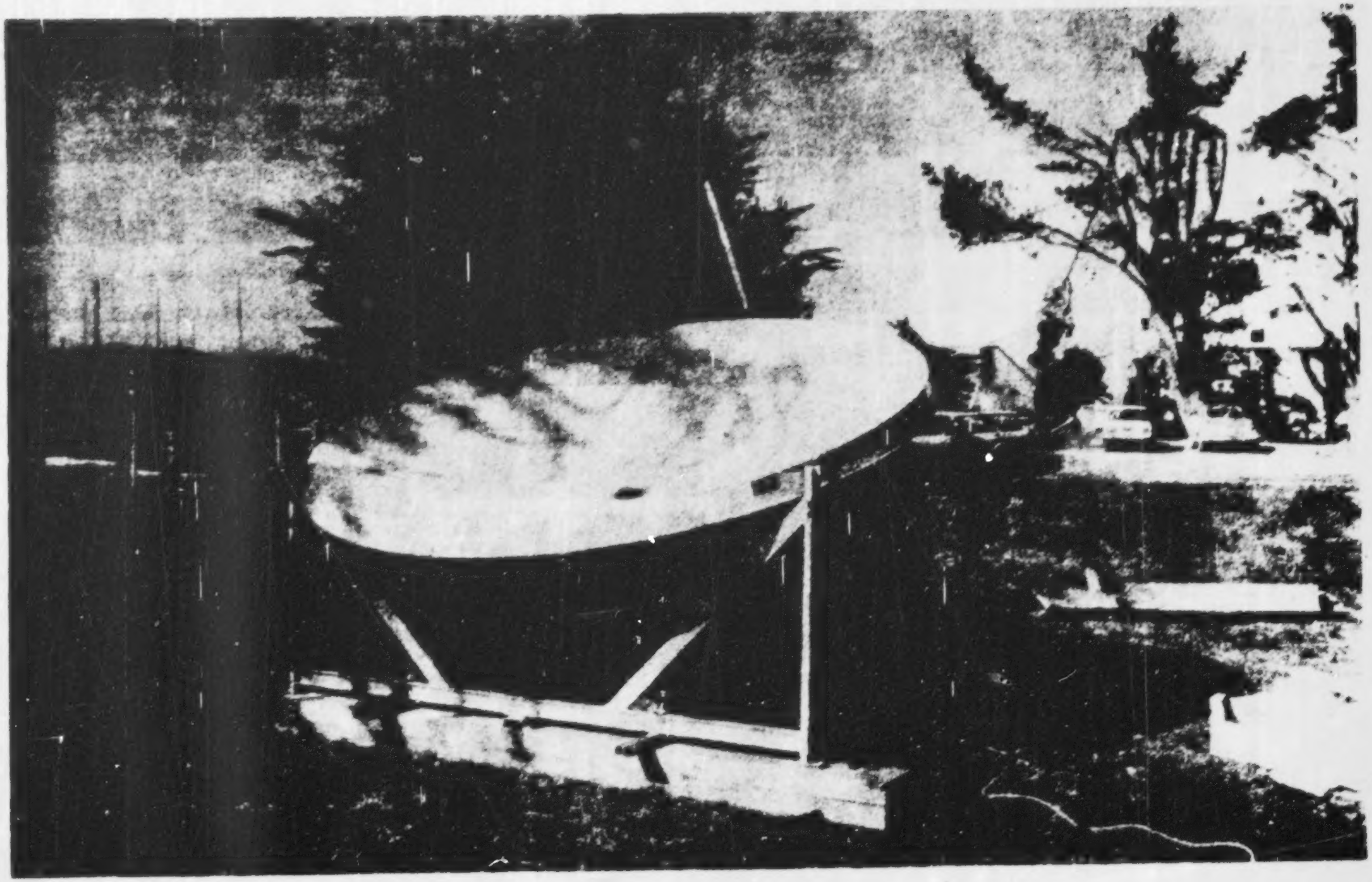

Figure 1 (e)

quality. Copies of the audio test tapes are available upon request.

To test data transmission, a punched tape was made on a model 33 ASR teletype and played through the tape reader to a Prentice P103-Orig modem. The modem was recorded on a Sony TC-40 cassette recorder. The cassette was taken to Point Reyes and played through the satellite channel during the tests. The received signals were recorded on another cassette which was played back through Prentice P103-Ans modem to the same teletype that was used to make the test tape. Thus, two small cassette tape recorders were intermediate steps for the signals. The audio level fed to the recorder in making the test tape and the level fed to the answer modem were checked and adjusted to be normal for the equipment. The TTY speed was 10 characters per second--110 baud nominal. The copy--24 lines, 1772 characters--was error free. See Table 2.

e. Test Deviations

For the Point Reyes, California station the Anik II satellite has performance characteristics equivalent to those for Anchorage, Alaska. This is about 5 dB better overall performance than the station will meet on the west coast of Alaska. For this reason and because of the very tight time constraints (from go ahead to demonstration was less than two months), manufacturers were allowed to deviate from nominal performance specifications if they could clearly identify the deviation and the ability to rectify the situation in production uints. There were three instances of such deviations and four other deviations that were corrected during the course of the tests. The three uncorrected deviations were:

BEST COPY AVAILABLE

Table 2

Anik TTY Test March 4, 1974
Setup: Original Antenna
C/N: 8.4 db

Received copy:

```
STANFORD UNIVERSITY TELETYPE TEST TAPE TRANSMISSION

THE QUICK BROWN FOX JUMPED OVER THE LAZY DOGS BACK 1234567890 STANFORD
THE QUICK BROWN FOX JUMPED OVER THE LAZY DOGS BACK 1234567890 STANFORD
THE QUICK BROWN FOX JUMPED OVER THE LAZY DOGS BACK 1234567890 STANFORD
THE QUICK BROWN FOX JUMPED OVER THE LAZY DOGS BACK 1234567890 STANFORD
ANIK TEST TAPE  10 CHARACTERS PER SECOND--ORIGINATE TONE
RECORDED ON SONY TC-40 RECORDER (CASSETTE)
STANFORD UNIVERSITY TELETYPE TEST TAPE TRANSMISSION

THE QUICK BROWN FOX JUMPED OVER THE LAZY DOGS BACK 1234567890 STANFORD
THE QUICK BROWN FOX JUMPED OVER THE LAZY DOGS BACK 1234567890 STANFORD
THE QUICK BROWN FOX JUMPED OVER THE LAZY DOGS BACK 1234567890 STANFORD
THE QUICK BROWN FOX JUMPED OVER THE LAZY DOGS BACK 1234567890 STANFORD


STANFORD UNIVERSITY TELETYPE TEST TAPE TRANSMISSION

THE QUICK BROWN FOX JUMPED OVER THE LAZY DOGS BACK 1234567890 STANFORD
THE QUICK BROWN FOX JUMPED OVER THE LAZY DOGS BACK 1234567890 STANFORD
THE QUICK BROWN FOX JUMPED OVER THE LAZY DOGS BACK 1234567890 STANFORD
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ANIK TEST TAPE  10 CHARACTERS PER SECOND--ORIGINATE TONE
RECORDED ON SONY TC-40 RECORDER (CASSETTE)
STANFORD UNIVERSITY TELETYPE TEST TAPE TRANSMISSION

THE QUICK BROWN FOX JUMPED OVER THE LAZY DOGS BACK 1234567890 STANFORD
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THE QUICK BROWN FOX JUMPED OVER THE LAZY DOGS BACK 1234567890 STANFORD
THE QUICK BROWN FOX JUMPED OVER THE LAZY DOGS BACK 1234567890 STANFORD
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(1) In the audio portion of the station, some energy from the internal power regulator leaked through the circuitry, giving a test tone to quieted noise ratio of about 43 dB, rather than 55 to 60. This "hum" source is easy to eliminate in production.

(2) The receive antenna gain is about 1 dB lower than specification because of connector and line losses incurred in the feed design used to meet the needs on such short notice; the receive feed is taken from the antenna focus rather than at the base of the waveguide feed as is common in production units. These losses would not be incurred with production feeds.

(3) Some losses (less than 1 dB) are incurred in the cabling and connectors used to connect antenna to antenna-mounted preamplifier. These losses would be minimized by elimination of unnecessary cable lengths and connector interfaces in production models.

The four deviations corrected during the tests were:

(1) The TWTA, power amplifier, being rented for the test had some intermittent problems and was returned to the factory for repair. For a week, an amplifier with one-half the power rating was used as a substitute until the higher power unit was returned.

(2) In the earliest tests, a receiver filter was not sufficiently narrow to reject image noise, decreasing receiver sensitivity by 3 dB. This was rectified by the second day of tests.

(3) During the teletype demonstration several runs used signal levels that over drove the modulator causing distortion and resulting in errors. This was corrected by using proper drive levels.

(4) The antenna used during most of the tests had an assembly intolerance that caused approximately 3 dB loss uplink and 2 dB loss downlink. The error was apparently due to the rush of the tests and would have been detected and corrected under normal production schedules. The antenna was replaced by the manufacturer by the end of the tests and the nominal performance obtained with the new unit.

During the demonstration to government and industry representatives on February 23, the first antenna was being used, thus simulating link performance under conditions equivalent to Alaskan west coast stations.

f. Adjacent Satellite Interference

There has been concern about the potential of small earth stations such as the Point Reyes station interfering with satellites parked in orbit near the position of the satellite being used by the station. To guard against this possibility, the Federal Communications Commission has established antenna performance regulations restricting the gain in directions toward adjacent satellites. They have also set limits to gain in directions that can interfere with other ground systems using the same frequencies.

Range measurements were made by the antenna manufacturer prior to and subsequent to delivery of the system. The antenna pattern does conform to the FCC regulations for protection of adjacent satellites (See Fig. 2). It does not meet the requirements for protection of nearby ground systems. We are informed that the "high performance" antenna from the same manufacturer, costing about $2,000 more, would meet ground system protection specifications. However, the FCC does provide for local coordination with other ground systems as an alternative to this requirement, and we recommend that this alternative be pursued.

In the Point Reyes tests, measurements of antenna position and satellite received power are not as precise as can be obtained on a test range. However, it was possible to demonstrate protection of adjacent satellite systems. The 10 ft. antenna was pointed at different angles from the satellite and the signal from the satellite monitored on the spectrum analyzer at the 30 ft. RCA ground station also located at

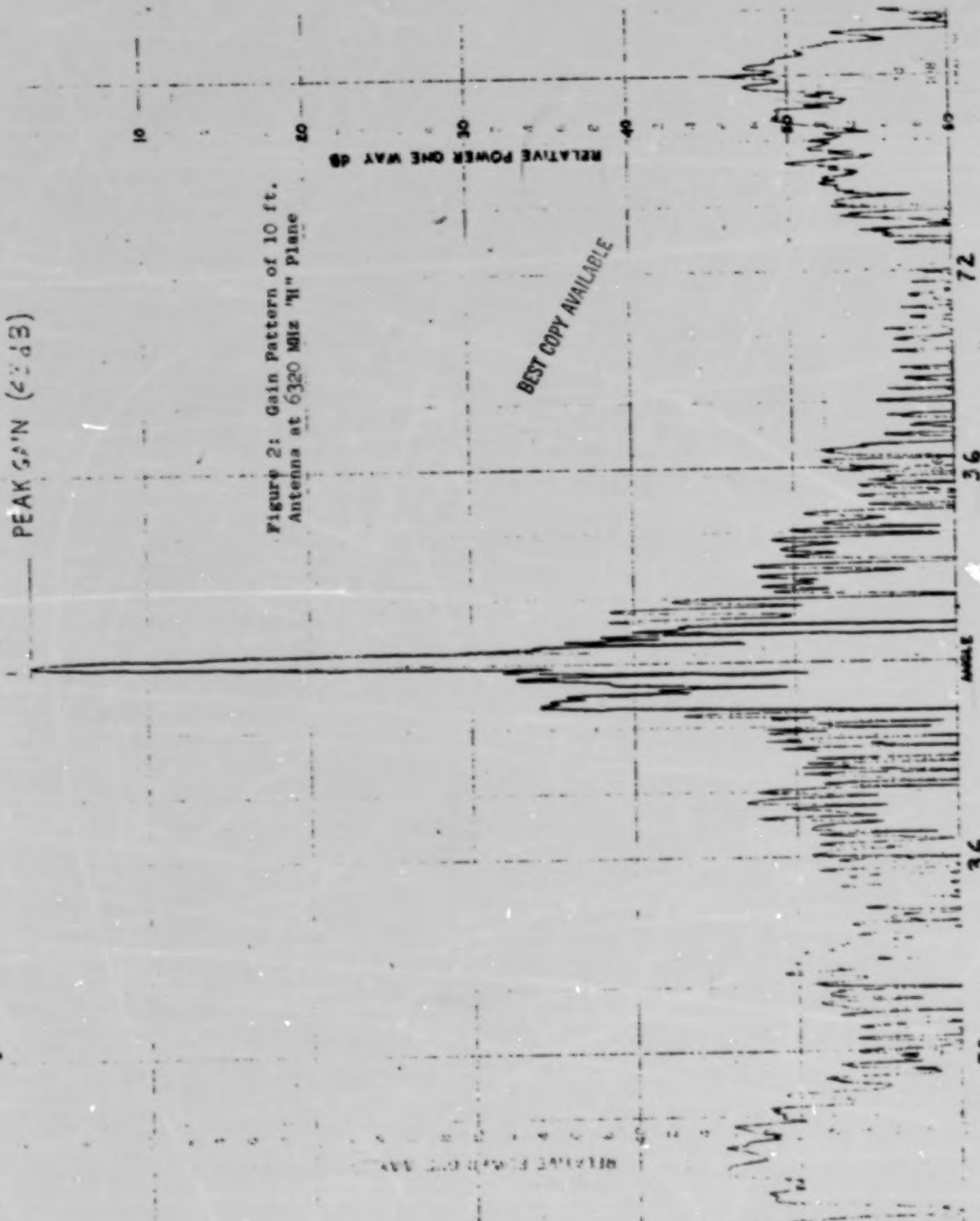

Figure 2: Gain Pattern of 10 ft. Antenna at 6320 MHz "H" Plane

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Point Reyes. This station has a nominal G/T of about 34 dB. With the 10 ft. antenna pointed from 1° to 2° off of the satellite, the signal had dropped about 11 to 12 dB below its highest level. With the antenna from 2° to 3° off the satellite, the signal was not visible above the system noise on the RCA analyzer, even with the 10 kHz bandwidth filter. The 10 ft. antenna was pointed to 4° and 5° from the satellite, but the signal was gone.

It was obvious that the 10 ft. antenna transmitting to a satellite 5° away from Anik II would have been completely undetectable in a system using Anik II.

g. Manufacturers

Our main contractors for the experiments were California Microwave, Inc. for the electronics and Westinghouse Corporation for the antenna system. The channel equipment was built by California Microwave, the preamplifier by Watkins Johnson, and the laboratory TWTA by Singer The antenna was built by Prodelin, Inc.

RCA Globcom furnished the satellite time and allowed use of the Point Reyes site at no charge.

h. Attachments

1. April 30, 1974 letter from Prodelin
2. Station license application

A-185

Prodelin Inc.

Prodelin

HIGHTSTOWN, NEW JERSEY • 08520
AREA CODE 609-448-2800
TELEX 843494

April 30, 1974

Mr. Mike Sykes
Room 225, Durand Building
Stanford Electronics Lab
Stanford, California 94305

Dear Mike:

Enclosed are the radiation limit patterns for the antenna system that we provided for the Point Reyes experiment. I am sorry for the delay but our engineering department wanted more time to re-test the unit after its return.

I emphasize that these are tentative limits based on only one feed system, however, they do indicate the type patterns that would be expected from a production antenna. It is anticipated that a similar antenna, but one conforming to the present FCC specifications, would cost from 80 to 100 percent more.

If I may be of further assistance, please feel free to call.

Very truly yours,

Paul Caffrey

Paul Caffrey
Systems Engineer

PC:gl
enclosure

REV. ______________ **Prodelin Inc.** NO. ______________

APPROVED A HIGHTSTOWN, N.J. SANTA CLARA, CALIF. DATE 4/3[illegible]/[illegible]4

RADIATION PATTERN

SIZE 10 FT.

CAT. NO. PA192-137-1

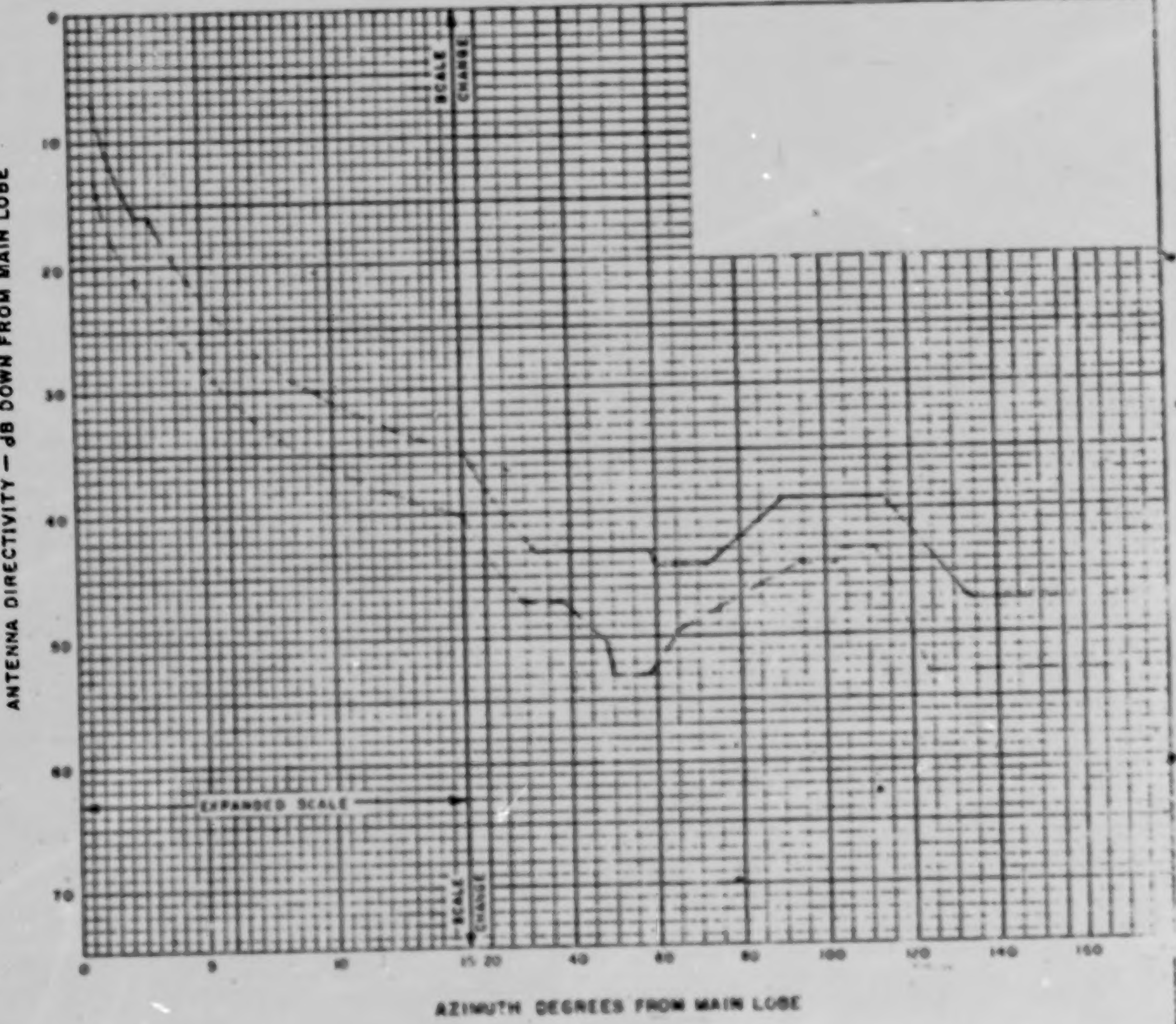
TYPE

FREQ. 3.7 - 4.2 GHz, 5.92 - 6.425 GHz

GAIN 39 dBi at 4.0 GHz, 43 dBi at 6.0 GHz

——— Response for 4.0 GHz

- - - - - - - Response for 6.0 GHz



FCC Form 442
October 1970

Form Approved
Budget Bureau No. 52-R043.16

Federal Communications Commission

APPLICATION FOR NEW OR MODIFIED RADIO STATION CONSTRUCTION PERMIT UNDER PART 5 OF FCC RULES

INSTRUCTIONS

1. Submit in duplicate direct to the Federal Communications Commission, Washington, D.C. 20554.
2. Before this application is prepared applicant should refer to the applicable part or parts of the Rules and Regulations of the Commission, copies of which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402
3. If a corporation, state corporate name; if a partnership, state names of all partners and the name under which the partnership does business; if an unincorporated association, state the name of an executive officer, the office held by him, and the name of the association. If this application involves a station that is now authorized, the name herein shown must correspond exactly with that shown on current authorization.
4. No fees required with this application.

1. Is the applicant (Check one)

Individual ☐ Partnership ☐
Association ☐ Corporation ☒

(If applicant is a partnership show the following information for each member of the partnership)

Is applicant a citizen of the United States? Yes ☐ No ☐

If citizenship is claimed by reason of birth, state

Date of birth	Place of birth

If citizenship is claimed by reason of naturalization

Date and place of birth	Date and place of issuance of final certificate of naturalization
Certificate number	Court authorizing issuance of certificate

If citizenship is claimed by reason of naturalization of a parent

Name of parent	Age of applicant when certificate was issued
Date and place of birth	Date and place of issuance of final certificate of naturalization
Certificate number	Court authorizing issuance of certificate

2. Is applicant a representative of an alien or of a foreign government? Yes ☐ No ☒

3. If applicant is a corporation, including municipal corporation

Under laws of what State or country is it organized? California	Where is applicant's principal office? Stanford, Calif.

Is more than one-fifth of capital stock owned of record or may it be voted by aliens or their representatives or by a foreign government or representative thereof, or by any corporation organized under the laws of a foreign country? Yes ☐ No ☐
N/A

Is any director or officer an alien? If "Yes", state name and position of each Yes ☐ No ☒

State names and addresses of all stockholders owning and/or voting 10 percent or more of applicant's stock and percentage held by each
N/A - Applicant is a nonprofit trust, having no shares of stock or stockholders.

File No. Call

Name of applicant (See Instruction 3)
THE BOARD OF TRUSTEES OF THE
LELAND STANFORD JUNIOR UNIVERSITY

Post office Address
105 Encina Hall
Stanford, California, 94305

4. Purpose of this application (See Instruction 1)

a. Class of station Fixed, earth
b. Nature of service Experimental (research)
c. New station ☒
d. Changes in existing station (File No. ____ (of current license) Call ____)
e. Modification of valid construction permit (File No. ____ (of construction permit) Call ____)

If (d) or (e) have been checked, indicate nature of proposed construction

1. Replace transmitter	☐	4. Change location	☐
2. Add. transmitter	☐	5. Change antenna	☐
3. Increase power	☐	6. Other changes (Use separate sheet)	☐

What is applicant's principal business?
Education and research

5. If applicant is a corporation

Is applicant directly or indirectly controlled by any other corporation? If "Yes", give name and address of each controlling corporation Yes ☐ No ☒

Under laws of what State or country is corporation organized?

Is more than one-fourth of capital stock of such corporation owned of record or may it be voted by aliens, their representatives, or by a foreign government or representative thereof, or by any corporation organized under the laws of a foreign country? Yes ☐ No ☐

Is any director or officer an alien? If "Yes", state name and position of each Yes ☐ No ☐

Is the above-described controlling corporation in turn a subsidiary? If "Yes", attach additional sheets answering Paragraph 5, inclusive, for each company to and including the organization having final control. Yes ☐ No ☐

6. If application is made in behalf of an unincorporated association

Purpose of the association	Number of members

State number of alien members (if any)

Is any director or officer an alien? If "Yes", state name and position of each Yes ☐ No ☐

(Attach copy of the Articles of Association or bylaws, certified by an appropriate officer of the organization)

14. a. What apparatus is included as an integral part of the transmitter for automatically holding the frequency within the allowed frequency tolerance? All frequencies derived by phase-locking to 5 MHz reference.

b. Within how many cycles or within what percentage of the assigned frequency is this apparatus designed or guaranteed by the manufacturer to hold the operating frequency?

1×10^{-8} parts per day

15. What provision will be made for measurement and periodic checking of the station frequency? Measurement prior to each test session with microwave frequency counter.

16. Estimated cost to establish proposed facilities

a. Transmitter (ready for service)	$ 12,000
Other items (state the nature and amount applicable to each)	$ 3,000

Antenna 1,500
Integration and testing 1,500

TOTAL ESTIMATED COST	$ 15,000

17. Proposed location of transmitter

Fixed ☒ Mobile ☐

a. If permanently located at a fixed location give

State California	County Marin
City or town Point Reyes	Street and number N/A
North latitude 38° 05' 45"	West longitude 122° 56' 45"

b. If mobile specify the exact area of operation.

N/A

18. Give commercial or Government RECEIVING station antenna systems known to be located within 3 miles of proposed location of transmitter.

Co-located with RCA Point Reyes satellite and HF radio site. See FCC File 55DSE-P-71 for complete description of RCA site and surrounding area.

19. Will the antenna extend more than 20 feet above the ground or natural formation, or if mounted upon an existing man-made structure, will it extend more than 20 feet above such structure?

Yes ☐ No ☒

20. If the answer to the above question is "Yes", give the following (SEE FOOTNOTE BELOW):

Overall height above ground to tip of antenna	N/A	ft.
Distance to nearest aircraft landing area	N/A	ft.
Elevation of ground, at antenna site, above mean sea level	N/A	ft.

List any natural formations or existing man-made structures (hills, trees, water tanks, towers, etc.) which, in the opinion of the applicant, would tend to shield the antenna from aircraft and thereby minimize the aeronautical hazard of the antenna.

N/A

21. Is the transmitter to be operated with licensed operator on duty at a remote control point only? Yes ☐ No ☒
If "Yes", the following information must be furnished.
(If licensed operator is to be on duty at the transmitter, data required by this item may be omitted.)

a. Location of remote control point
(If more than one remote control point is involved, attach supplementary sheet giving location of each remote control point, plan of operation, etc.)

State N/A	County N/A
City or town N/A	Street and number N/A

b. What is the airline distance between transmitter location and remote control point?

N/A

c. By what means will the transmitter be rendered inaccessible to unauthorized persons?

N/A

d. Can transmitter be placed in an inoperative condition from the remote control point? Yes ☐ No ☐

N/A

e. Describe below the equipment to be used to enable the operator at the remote control point to determine when there is a deviation from the terms of the station license or when operation is not in accordance with the Commission's rules governing the class of station involved.

N/A

FOOTNOTE

FCC Form 401-A, and required exhibits, shall be submitted in triplicate with this application in all cases when:

(1) The antenna structures proposed to be erected will exceed an over-all height of 170 feet above ground level, except that where the antenna is mounted on top of an existing man-made structure and does not increase the over-all height of such man-made structure by more than 20 feet, no Form 401-A need be filed, or

(2) The antenna structures proposed to be erected will exceed an over-all height of 1 foot above the established airport (landing area)* elevation for each 200 feet of distance, or fraction thereof, from the nearest boundary of such landing area, except that where the antenna does not exceed 20 feet above the ground or if the antenna is mounted on top of an existing man-made structure or natural formation and does not increase the over-all height of such man-made structure or natural formation by more than 20 feet, no Form 401-A need be filed.

---

* Landing area, as defined in Part 17 of the Commission's Rules: "Landing Area" means any locality, either of land or water, including airports and intermediate landing fields, which is used, or approved for use, for the landing and take-off of aircraft, whether or not facilities are provided for the shelter, servicing, or repair of aircraft, or for receiving or discharging passengers or cargo.

7. Is applicant directly or indirectly, through stock ownership, contract, or otherwise, interested in the ownership or control of any other radio stations? Yes ☒ No ☐

8. State applicant's relation to proposed station (if applicant is to be neither owner or lessee, state nature of applicant's interest in use and control of station)

Applicant will own and operate station in partial fulfillment of U.S. Government contract NIH 71-4718 with the National Institute of Health. Portions of the station equipment are being loaned to the applicant by Westinghouse Electric Corporation and California Microwave, Inc., for the duration of the experimental period.

(If not owner, attach copy of agreement showing applicant's interest in station)

If applicant is not to be owner of station, who is?

Will applicant have absolute control of station, both as to physical operation and service conducted? Yes ☒ No ☐
If "No", attach copy of any contract which may in any way affect applicant's right to do so

9. State fully the facts showing applicant's financial ability to construct and operate this station.

Station will be constructed and operated with funds provided by U.S. Government contract NIH 71-4718 with the National Institute of Health.

10. Has the applicant, or any person directly or indirectly controlling the applicant, been finally adjudged guilty by any Federal court of unlawfully monopolizing, or attempting unlawfully to monopolize radio communication, directly or indirectly, through control of manufacture or sale of radio apparatus, exclusive traffic arrangement, or any other means, or of unfair methods of competition? Yes ☐ No ☒

11. Is applicant directly or indirectly engaged in the business of transmitting and/or receiving for hire messages of any cable, wire-telegraph, or telephone lines or systems? Yes ☐ No ☒

12. Frequency requested and particulars of operation of the proposed station

Frequencies (1)	Hours (2)	Power (3)	Emission (4)	Modulating frequency cycles (5)	Points of communication
6320.00 MHz	Unlimited	800 kW	27F3	3400 Hz	See Remarks

1. List frequencies separately, indicating whether kilocycles or megacycles.
2. Indicate as unlimited, day only, continuous, etc. (This item refers to intended hours of use of the specific frequency.)
3. Effective radiated power. Specify whether watts or kilowatts. If pulse emission specify peak power.
4. List each type of emission separately for each frequency. If pulse emission specify pulse duration and pulse repetition rate.
5. Give maximum modulating frequency employed in normal operation opposite type of emission involved.

REMARKS:

Station will be used for loop-through tests from the RCA satellite communications site at Point Reyes, California through the RCA leased transponder on the Anik II satellite owned by Telesat Canada and back to the RCA site at Point Reyes.

13. Description of transmitting apparatus proposed to be installed

State number of transmitters 1	Make See Exhibit 1	Type or Model No. See Exhibit 1
Type of oscillator circuit Cavity-tuned oscillator phase locked to 5 MHz standard with 1×10^{-8} parts/day stability (See Exhibit 1)	Type or class of modulation Frequency modulation with ± 10 kHz peak test-tone deviation modulator is a voltage controlled multivibrator phase-locked to 5 MHz standard.	Plate power supply for last radio stage Rated Current See Exhibit 1 Rated Voltage

FCC Form 440 Page 4

22. Location of receiving equipment associated with this station

State California	County Marin
City or town Point Reyes	Street and number None
North latitude 38° 05' 45"	West longitude 122° 56' 45"

23. Give definite facts why the operation of the station will be in the public convenience, interest, or necessity.

Operation of this station is in partial fulfillment of U.S. Government contract NIH 71-4718 with the National Institute of Health. The operation of this station is intended to confirm performance of transportable satellite communication terminals that can supply two-way voice communications to remote Alaskan villages. Experiments using the ATS-1 satellite showed that effective communications can greatly improve health care in these villages. See Exhibit 2.

24. Supplementary statements as required for the particular class of station applied for are attached and identified as Exhibit(s):

Station will be constructed and operated under U.S. Government contract, thereby fulfilling requirements of section 5.57

25. Any exhibits referred to herein and those attached hereto, described and identified as follows, are certified to be true and correct. (List here all exhibits attached to the application)

Exhibit 1 -- Description of station

Exhibit 2 -- Medical communication in Alaska by satellite

CERTIFICATION

The applicant waives any claim to the use of any particular frequency or of the ether as against the regulatory power of the United States because of the previous use of the same whether by license or otherwise, and requests a construction permit in accordance with this application. The undersigned hereby certifies that the statements in this application are true, complete and correct to the best of his (her) knowledge and belief, and are made in good faith

Signed and dated this 18th day of January, 19 74.

Name of Applicant THE BOARD OF TRUSTEES OF THE LELAND STANFORD JUNIOR UNIVERSITY
(must correspond with name given on page 1)

By Robert R. Augsburger (print) Robert R. Augsburger (signature)

Title Vice President for Business and Finance
(designate appropriate classification below)

WILLFUL FALSE STATEMENTS MADE ON THIS FORM ARE PUNISHABLE BY FINE AND IMPRISONMENT.
U. S. CODE, TITLE 18, SECTION 1001.

☐ INDIVIDUAL APPLICANT
☐ MEMBER OF APPLICANT PARTNERSHIP
☒ OFFICER OF APPLICANT CORPORATION OR ASSOCIATION
☐ OFFICIAL OF GOVERNMENTAL ENTITY COMPETENT UNDER THE JURISDICTION TO SIGN FOR THE APPLICANT
☐ AUTHORIZED EMPLOYEE

F.C.C. - WASHINGTON, D. C.

EXHIBIT 1

Description of Station

1.0 SYSTEM PERFORMANCE GOALS FOR HEALTH APPLICATIONS

Following are the technical specifications for a system that can supply health communications between Alaskan medical centers and health aides located in remote villages. Characteristics of the services are as follows:

- At each village is a single voice channel transponder. The equipment is of the simplex variety (push to talk) and can monitor other calls through the satellite using the same satellite frequency. Its transmit and receive frequencies are fixed and can be changed only by a field modification. Power is from a 24 volt automobile battery recharged periodically by local electric generators.

- At each medical center is a voice transponder similar in every way to the village transponders except that it can be switched by mechanical switch to work on one to four satellite channels.

- Initially, all stations will use a single 24-hr/day simplex channel on Canada's Anik satellite. Routine traffic from different service areas would be assigned to different hours of the day. As requirements exceed one channel, additional channels would be added with different service areas being assigned to different channels.

- The system is to maintain voice communications with "intelligibility excellent" (13 to 16 dB SNR) with communications rain losses and station antenna pointing errors described below. Under normal conditions without these losses it should provide "quality good to excellent" (20 to 25 dB SNR).

2.0 ANIK CHARACTERISTICS

Alaska is off to one side of the satellite beam. Because of this the satellite performance is worse than its nominal design characteristics for Alaska. This degradation is dependent on how far west in Alaska the station is. It is also dependent on which transponder in the satellite is used. The satellite's performance is described below in terms of its transponder gain $[\mathrm{DBW/DBW/M^2}]$ which describes the Effective Radiated Power, ERP, in DBW that results from a given signal power density $[\mathrm{DBW/M^2}]$ arriving at the satellite. The transponder gains are given for the transmitter backed off at least 5 dB from saturation, the condition typical of voice circuit operation. Minimum gain is given for Anchorage and points east and for all

Alaska except for the Aleutian Chain. The gain is also given for Transponder I and for Transponder 12. The satellite being described is Anik II, located in equatorial orbit at 109° W.

TABLE I

Anik II Transponder Gains in the Direction of Alaska

[DBW/DBW/M^2]

	Anchorage and East	Alaska except Aleutians
Transponder I	119.9	114.9
Transponder 12	121.4	116.4

It should be noted that it appears to be technically possible to point the satellite beams slightly more westward without effecting services to Canadian users on the East Coast. This would cover all of Alaska except the Aleutians with the gain quoted above for Anchorage and East.

3.0 STATION PERFORMANCE WITH ANIK SATELLITE

The link performance calculations for an 'optimum' station are performed below. The calculation uses Transponder 1 for all Alaska except the Aleutians. [114.9 DBW/DBW/M^2]. Two conditions are estimated, one with no rain loss and station pointing error, and the other with these losses.

TABLE II

LINK PARAMETERS

Up-Link Frequency	6 GHz
Path Length to Satellite	41173 km
Down-Link Frequency	4 GHz
Satellite G/T On-Axis	-7 dB/Deg K
Satellite Intermod Relative to EIRP	-15 dB
Satellite Transponder Gain	114.9 dB/dB/M^2

LINK CALCULATIONS

	With Loss	Without Loss	
Transmitter Power (30 watts)	14.8	14.8	dB
Station Antenna Diameter	10	10	ft.
Transmit Gain	43.0	43.0	dB
Transmit Line Loss	1.5	1.5	dB
Transmit Point Loss	.5	-	dB
Up-Link Rain Loss	1	-	dB
Flux at Satellite	-108.5	-107.0	dB
C/kT Up	73.1	74.6	dB
EIRP from Satellite	6.4	7.9	dB
Rain/Atmosphere Loss Down	.7	-	dB
Receive Pointing Loss	.3	-	dB
Receive Line Loss	.8	.8	dB
Preamplifier Noise (TDA4.5dBNF)	525	525	°K
System Noise Temp., Incl. Rain	615	570	°K
Receive Gain	39.5	39.5	dB
Receive G/T	11.6	11.8	dB/°K
C/kT Down	48.0	50.7	dB/Hz
RF Bandwidth	20	20	kHz
C/IM Noise Density	58	58	dB/Hz
C/kT Total	47.6	50.0	dB/Hz
RF Bandwidth	20	20	kHz
C/N Ratio in RF Bandwidth	4.6	7.0	dB
Audio Bandwidth	3.4	3.4	kHz
Weighted Test Tone to Noise Ratio	22.3	24.7	dB
Approximate* Voice/Noise Ratio	12.3	18.7	dB

*Depends on specific characteristics of receiver

4.0 SYSTEM DESCRIPTION

The system is shown in its overall form in attached Figure 1. Incoming voice is used to modulate an FM carrier which is translated to the appropriate transmit frequency. The FM carrier is then amplified and applied to the antenna for transmission to the satellite in the 5.925 to 6.425 GHz band. In the receive direction the translated carrier (in the 3.7 to 4.2 GHz band) is received by the antenna, low noise amplified, downconverted, and passed to the receive FM channel equipment. The output of the threshold extension detector is the receive voice for connection to other terminal equipment (signaling equipment, echo suppressors, 2W/4W hybrids, etc.).

The common equipment includes a highly-stable reference oscillator, a transmit system pilot generator (which will not be used initially), a transmit summing network, a receive AFC pilot detector (also optional), a receive distribution amplifier, an IF-to-RF upconverter, and an RF-to-IF downconverter.

In the transmit direction the incoming voice line includes protection against excessive voltages. After amplification and low-pass filtering the voice signal is processed by a volume compressor and a special circuit to prevent excessive deviation. The voice signal is then applied to a low-noise FM modulator. The output of the modulator is applied to a mixer for conversion to the output IF. The output frequency is controlled by a VCO whose frequency is programmable to permit rapid frequency assignment when a demand access system is used. The actual transmit frequency is referenced to the station standard. The output of the transmit channel equipment is turned on by voice actuation, when desired, or it may be left on continually.

The receive part of the channel unit is downconverted twice, the first conversion to 10.7 MHz and the second to 455 kHz. The receive channel frequency is controlled by the VCO used with the first conversion. This VCO is a part of a programmable frequency synthesizer to permit rapid frequency assignment when a demand access system is used. The synthesizer is referenced to the highly stable station standard. The 455 kHz detector uses a phase-lock demodulator for threshold extension. A delay line between the output of the detector and the voice equipment assures that the phase-lock detector has achieved synchronization with the incoming carrier before its output is connected to the voice frequency output line. The signal is then processed by a click eliminator and the expandor part of the compandor.

Emphasis is used to give output noise which is essentially flat with frequency. This gives an improvement of several decibels in system signal-to-noise ratio over that obtainable without the emphasis. The emphasis is 6 dB per octave to effectively obtain phase rather than frequency modulation. The signal-to-noise improvement obtained is discussed in more detail in the following section.

The upconverter and downconverters both use special microwave signal sources which are required to maintain low FM noise in the baseband spectrum between 300 and 3400 Hz. These same sources are referenced to the stability of the station standard as required to maintain the overall frequency stability, except that the first oscillator in the downconverter can optionally be part of the receive AFC loop that compensates for the drifts of the satellite oscillator.

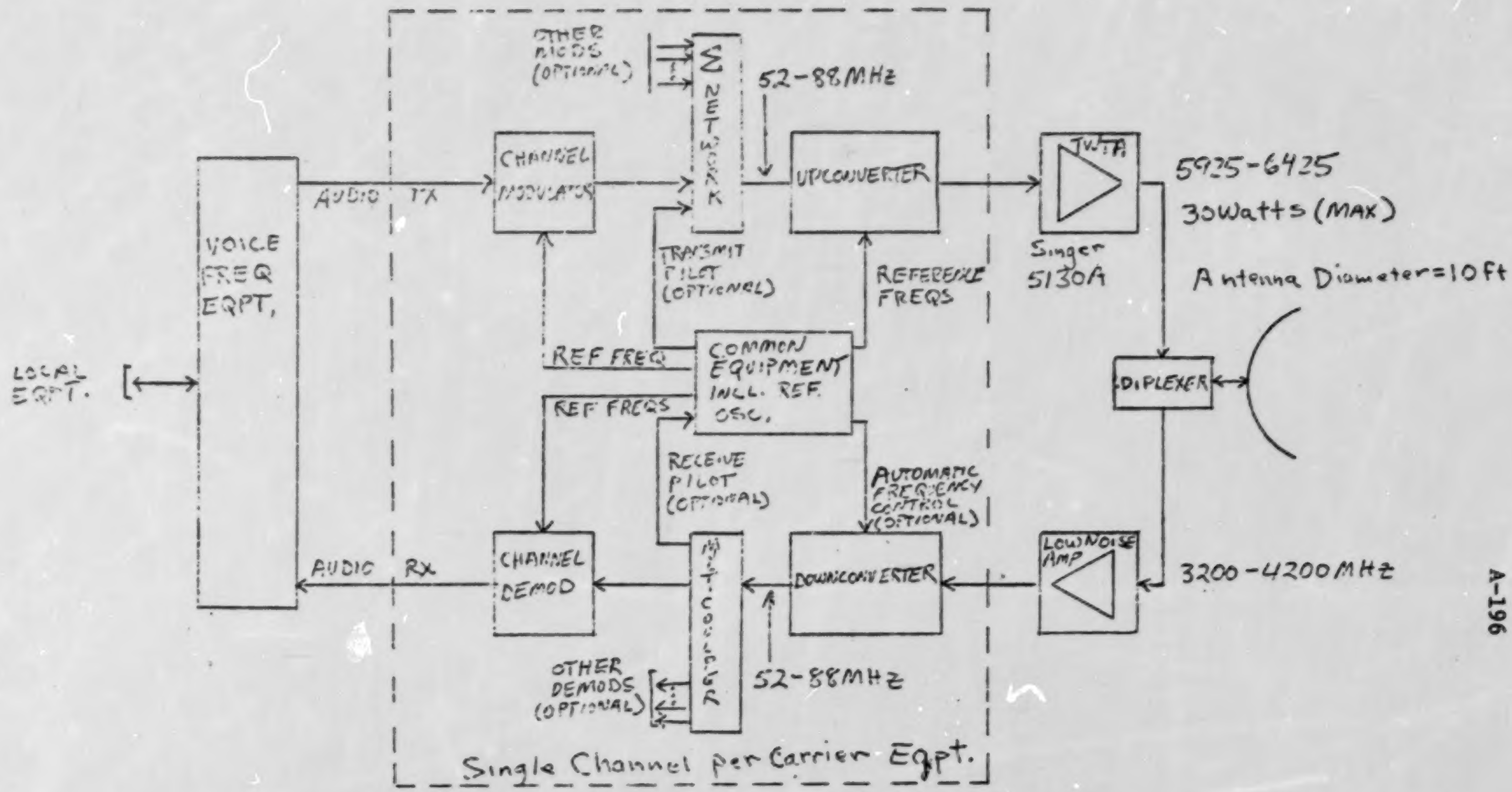

LOCAL EQPT.
VOICE FREQ EQPT,
AUDIO TX
AUDIO RX
OTHER MODS (OPTIONAL)
Σ NETWORK
52-88MHz
CHANNEL MODULATOR
UPCONVERTER
TWTA
Singer 5130A
5925-6425
30Watts (MAX)
Antenna Diameter=10ft
TRANSMIT PILOT (OPTIONAL)
REFERENCE FREQS
REF FREQ
COMMON EQUIPMENT INCL. REF. OSC.
REF FREQS
DIPLEXER
RECEIVE PILOT (OPTIONAL)
AUTOMATIC FREQUENCY CONTROL (OPTIONAL)
CHANNEL DEMOD
M-T-COUPLER
DOWNCONVERTER
LOW NOISE AMP
3200-4200MHz
OTHER DEMODS (OPTIONAL)
52-88MHz
Single Channel per Carrier Eqpt.

Figure 1 - OVERALL STATION BLOCK DIAGRAM

FCC Form 440 A
November 1966

FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D. C. 20554

Form Approved
Budget Bureau No. 52-R166

SUPPLEMENTAL INFORMATION FOR APPLICATIONS IN THE EXPERIMENTAL RADIO SERVICE INVOLVING GOVERNMENT CONTRACTS

INSTRUCTIONS:
1. File in TRIPLICATE with the Federal Communications Commission, Washington, D. C. 20554.
2. If the experimental project described herein carries a security classification, this document must be classified accordingly. The Commission will handle each such case in accordance with applicable security regulations.

1. NAME AND ADDRESS OF APPLICANT *(MUST CORRESPOND WITH APPLICATION)*
THE BOARD OF TRUSTEES OF THE LELAND STANFORD JUNIOR UNIVERSITY
105 Encina Hall, Stanford, California, 94305

2. CONTRACT NUMBER: NIH 71-4718

3. AGENCY PLACING CONTRACT: National Institute of Health

4. NAME OF PRIME CONTRACTOR, IF OTHER THAN APPLICANT
Applicant

5. NAME, ADDRESS AND TELEPHONE NUMBER OF ENGINEER RESPONSIBLE FOR THIS PROJECT
Michael J. Sites, 225 Durand Bldg, Stanford University, Stanford, CA 94305
(415) 321-2300 X 3595

6. BRIEF DESCRIPTION OF PROJECT AND PURPOSE OF OPERATION
Demonstrate feasibility of using small earth terminals in conjunction with an existing domestic satellite (Anik II) to provide voice communication into remote areas. Primary application would be for providing reliable communications between doctors of the Indian Health Service and native para-medical personnel located at remote native settlements in Alaska which have no existing telephone service.

7. LOCATION OF PROPOSED STATION *(IF MOBILE, GIVE AREA OF OPERATION; IF FIXED, COMPLETE ITEM 8)*
Point Reyes, California

8. GEOGRAPHIC COORDINATES	38° 05' 45" N. LAT.	122° 56' 45" W. LONG.
9. NUMBER OF TRANSMITTING EQUIPMENTS TO BE OPERATED	FIXED 1	AIRCRAFT 0
	LAND MOBILE 0	OTHER *(specify)* 0

10. TECHNICAL DETAILS *(Use a separate column for each frequency or band of frequencies)*

	1	2	3	4	5
FREQUENCY	6320.00 MHz				
POWER ERP*	800 kW				
TYPE OF EMISSION**	F3				
BANDWIDTH OF EMISSION (KC)**	27				
PULSE DURATION	N/A				
PULSE REPETITION RATE	N/A				

* Effective radiated power in watts, kilowatts or megawatts
**If a complex emission (A9, F9, P9 etc) is to be used, describe in detail below.
Refer to Sections 2.202 and 5.103 of the Commission's Rules.

SIGNATURE OF PERSON COMPLETING THIS FORM: Michael J Sites

TITLE: Research Associate

F.C.C. - Washington, D. C.

6.a. If the answer to Question 6 on the reverse side is "YES", give the following:

Overall height above ground to tip of antenna ________ ft.

Distance to nearest aircraft landing area ________ ft.

Elevation of ground, at antenna site, above mean sea level ________ ft.

6.b. If the answer to Question 6 on the reverse is "YES", in the opinion of the applicant, are there any natural formations or existing man-made structures (hills, trees, water tanks, towers, etc.) which would tend to shield the antenna from aircraft and thereby minimize the aeronautical hazard of the antenna? ____ YES ____ NO

If "YES", list such natural formations or existing man-made structures.

7. CONTINUED

No changes

REMARKS:

None

A-199

FCC Form 411
November 1973

Form Approved
O.M.B. No. 52-R0230

APPLICATION FOR NEW OR MODIFIED EXPERIMENTAL RADIO STATION LICENSE UNDER PART 5 OF FCC RULES

APPLICANTS SHOULD NOT USE THIS BLOCK

File Number	Call Sign

INSTRUCTIONS

A. This form is to be used in all cases when applying for an Experimental Radio Station License, or Modification thereof, under Part 5 of the FCC Rules.

B. Submit in duplicate direct to the Federal Communications Commission, Washington, D. C. 20554.

C. The name of the applicant must be stated exactly as it appears on the Construction Permit which is being covered, or the License which is being modified, explain name-change modifications under Remarks.

D. If there has been no change in any of the information submitted in the application for the Construction Permit being covered, or the authorization issued pursuant thereto, applicant need answer only question 1,2,3, and 4 and sign the Certification.

E. No fees are required with this application.

1.(a) Name of Applicant (See instruction C) THE BOARD OF TRUSTEES OF THE LELAND STANFORD JUNIOR UNIVERSITY

(b) Mailing Address (number, street, city, state, ZIP Code)
105 Encina Hall
Stanford, California 94305

2.(a) Class of Station Fixed Earth

(b) Nature of Service Experimental (Research)

(c) Call Sign not assigned

3. Has there been any change in any of the information submitted in the application for the Construction Permit which is being covered herein or the authorization issued pursuant thereto?

____ YES X NO

(See Instruction D)

4. Purpose of application
License to cover construction permit X YES ____ NO
Modification of License 1/ ____ YES

Present File No.____

1/ Specify in questions 5, thru 8, or under Remarks desired modification.

5. TRANSMITTER LOCATION. If portable/mobile, give geographical area of proposed operation, or, give State, City, County, Street & No. and Latitude/Longitude of fixed location:

Area of Operation	State	City	County	Street & No.	Latitude / Longitude
Fixed	California	Pt. Reyes	Marin	N/A	Latitude 38° 05' 45" N Longitude 122° 56' 45" W

6. ANTENNA STRUCTURE. Will the antenna extend more than 20 feet above the ground or natural formation, or if mounted upon an existing man-made structure, will it extend more than 20 feet above such structure? ____ YES X NO (If "yes" see Reverse)

7. Give details of any changes in transmitter(s) or antenna systems on Reverse. No changes

8. Specify below, exactly, all particulars of desired operations.

Frequencies (1)	Hours (2)	Power (3)	Emission (4)	Modulating frequency cycles (5)	Points of communication
6320.00 MHz	unlimited	800 kW (see remarks)	27F3	3400	See remarks

1. List frequencies, separately, indicating whether kilohertz or megahertz.
2. Indicate as unlimited, day only, continuous, etc. (This item refers to intended hours of use of the specific frequency.)
3. Effective radiated power. Specify whether watts or kilowatts. If pulse emission specify peak power.
4. List each type of emission separately for each frequency. If pulse emission specify pulse duration and pulse repetition rate.
5. Give maximum modulating frequency employed in normal operation opposite type of emission involved.

REMARKS: Output power of transmitter is 40 W; antenna gain is 43 dB Station will be used for loop-through testing from RCA Point Reyes site through the Anik II satellite and received at the RCA Point Reyes site.

CERTIFICATION

All the statements made in the application and attached exhibits are a material part hereof and are incorporated herein as if set out in full in the application. The applicant waives any claim to the use of any particular frequency or of the ether as against the regulatory power of the United States because of the previous use of the same, whether by license or otherwise, and request an authorization in accordance with this application.

I CERTIFY that the statements in this application are true, complete, and correct to the best of my knowledge and belief and are made in good faith.

BY Robert R. Augsburger
(print name of person signing)

Robert R. Augsburger
(signature - describe [illegible] by checking box below)

1/18/7
(date)

☐ INDIVIDUAL APPLICANT
☐ MEMBER OF APPLICANT PARTNERSHIP
☒ OFFICER OF APPLICANT CORPORATION OR ASSOCIATION
☐ AUTHORIZED EMPLOYEE

WILLFUL FALSE STATEMENTS MADE ON THIS FORM ARE PUNISHABLE BY FINE AND IMPRISONMENT. U.S. CODE, TITLE 18, SECTION 1001.

A-200

Exhibit 2

MEDICAL COMMUNICATION IN ALASKA BY SATELLITE

Heather E. Hudson, M.A. & Edwin B. Parker, Ph.D.

Institute for Communication Research

Stanford University

Stanford, California

September 1973

Abstract

An experimental communication satellite has been used since late summer of 1971 to provide daily two-way radio contact between native health aides in remote Alaska communities and a Public Health Service doctor. Health aides, who after 12 weeks of training provide all of the primary health care in their communities, are now able to consult with a doctor concerning treatment of most of their cases where formerly radio contact was impossible six days out of seven. Doctors and health aides have accepted the experimental communication service as an integral part of the Alaska health care delivery system. The Public Health Service now has the problem of how to terminate or replace the experimental service without lowering the quality of health care the native people have learned to expect.

MEDICAL COMMUNICATION IN ALASKA BY SATELLITE

1. Introduction

A "satellite house call" probably sounds like an episode from a medical fantasy. And yet patients in 14 remote Alaskan villages can now receive consultation from a doctor--via communication satellite.

Health care is delivered in bush Alaska by the Alaska Area Native Health Service of the Public Health Service. Much of the native population is scattered in about 175 villages with populations between 25 and 500. The state is divided into 7 Health Service Units, each with a service unit hospital. The major referral hospital is the Alaska Native Medical Center at Anchorage. Health care in most of the villages is provided by a native health aide with up to 16 weeks of training by the Public Health Service. The health aide's tools are a basic drug kit, a manual, and a 2-way radio.

Although some communities have telephones, most of the villages can communicate with each other and with larger centers only by High Frequency (HF) radio. The health aides' back-up is the doctor at the service unit hospital who attempts to contact each aide by radio at a set time every day. This scheduled consultation is known as "doctor call." However, in practice, radio contacts may be very infrequent. HF radio is plagued by ionospheric disturbances which may cause "black-outs" lasting days at a time. The radios are usually not owned by the PHS but by other institutions such as the Bureau of Indian Affairs or the State-Operated Schools system. They may be located in a teacher's home or the school, where the health aide may be unable or unwilling to use the radio on a daily basis. In addition to such limitations on access, radio communication may further be hampered by infrequent maintenance of the equipment.

Tanana Service Unit in central Alaska, including some 21 villages many of which are on the Yukon and Koyukuk Rivers, has the worst communication problems in Alaska. The above factors, compounded by the mountainous terrain and distances of as much as 250 miles from village to hospital, make HF communication very unreliable. While some villages were able to maintain fairly regular schedules with the Tanana hospital, the health aide in one village (Beaver) had contacted the doctor by radio only once in the two years prior to installation of a satellite ground station in spring of 1973. Even a "working" radio can be less than wholly satisfactory. Bertha Moses, the health aide in Allakaket, an Athabaskan village on the Koyukuk River, described an emergency when she needed to contact the doctor at Tanana. Her HF radio could transmit messages, but she heard no reply. Fortunately, a village school teacher was able to tune his short wave receiver to the same frequency. Bertha radioed the doctor, and the teacher listened to the replies and then ran across the village to repeat them to Bertha so that she could continue her "conversation." The villages are typically without electricity and draw their water from the rivers. The Athabaskan Indian people live in log cabins and use wood for fuel. The one predominantly Eskimo community in the service unit is Anaktuvuk Pass, high in the Brooks Range. Here most people now live in prefabricated houses, although a few traditional sod huts remain in use.

Satellite communication was introduced to the Tanana region in late summer of 1971 as an experimental medical communication project financed by the National Library of Medicine's Lister Hill National Center for Biomedical Communication. Ground stations costing about $3,000 each were installed for the project by the University of Alaska's Geophysical Institute, which also has the maintenance contract and operates the "Minitrak" Alaskan base station at the University. NASA's ATS-1[*] communication satellite was used like a tall (22,000 mile high) tower providing line of sight communication to and from each of 26 ground station locations throughout the state, avoiding most of the interference plaguing radio communication between distant points in Alaska. The locations are shown in Figure 1. Initially, the sites included the service unit hospitals, the Alaska Native Health Center at Anchorage, 10 villages in the Tanana Service Unit, two on the north slope, and St. Paul, one of the Pribilof Islands in the Bering Sea. In the spring of 1973, four little-used stations were moved to additional villages in the Tanana Service Unit where they are now in daily use. The communication system is being operated by the Indian Health Service.

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[*] Application Technology Satellite-1 of the National Aeronautics and Space Administration

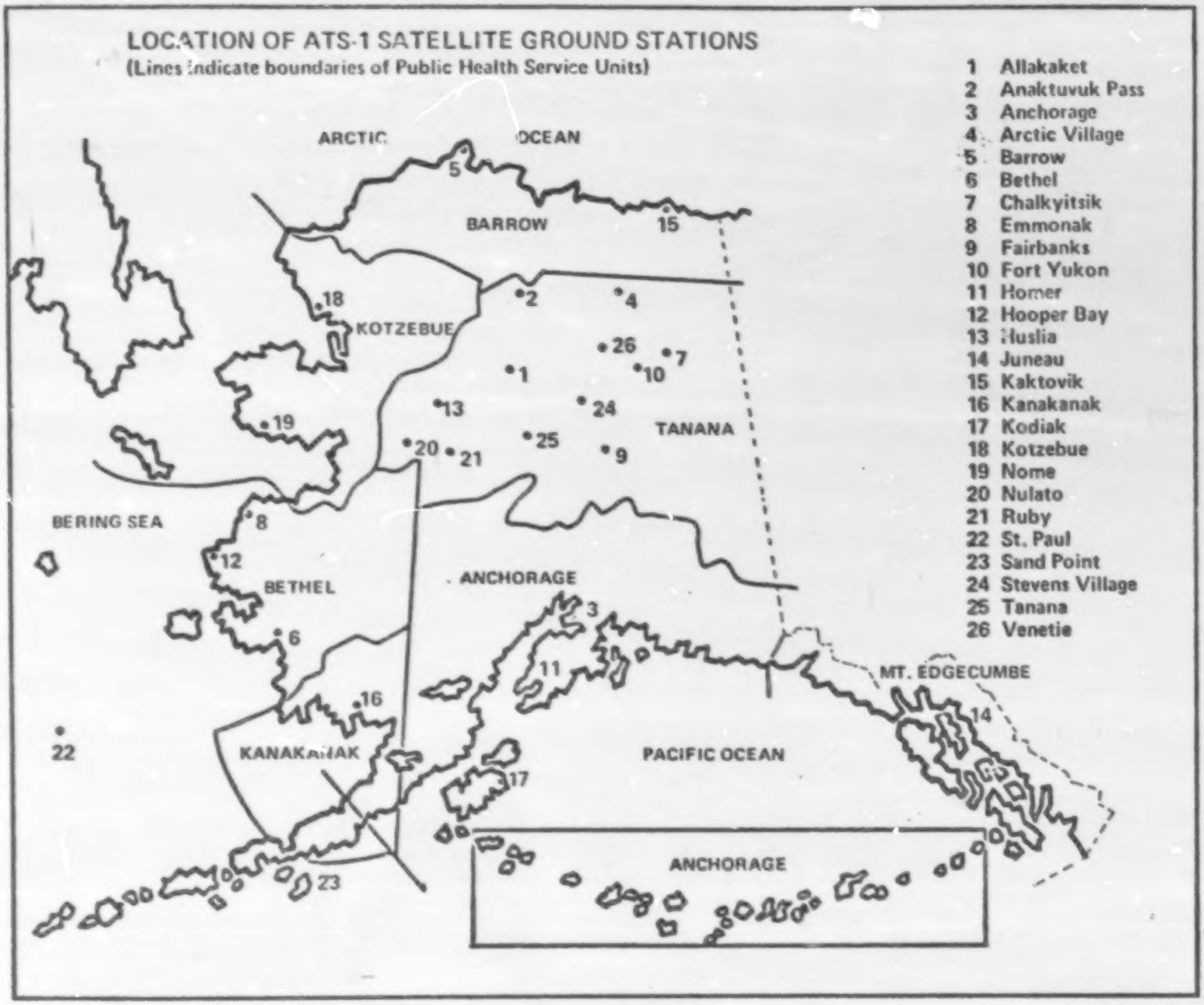

LOCATION OF ATS-1 SATELLITE GROUND STATIONS
(Lines indicate boundaries of Public Health Service Units)
ARCTIC OCEAN
BARROW
KOTZEBUE
TANANA
BERING SEA
BETHEL
ANCHORAGE
KANAKANAK
PACIFIC OCEAN
MT. EDGECUMBE
ANCHORAGE
1 Allakaket
2 Anaktuvuk Pass
3 Anchorage
4 Arctic Village
5 Barrow
6 Bethel
7 Chalkyitsik
8 Emmonak
9 Fairbanks
10 Fort Yukon
11 Homer
12 Hooper Bay
13 Huslia
14 Juneau
15 Kaktovik
16 Kanakanak
17 Kodiak
18 Kotzebue
19 Nome
20 Nulato
21 Ruby
22 St. Paul
23 Sand Point
24 Stevens Village
25 Tanana
26 Venetie

Figure 1

Location of ATS-1 satellite ground stations

ATS-1, first in NASA's series of Applied Technology Satellites, was launched in 1966 with a life expectancy of two years. Solar cells permit recharging of batteries for satellite power for the Alaskan experiments, which use the still functioning VHF (Very High Frequency) transponder. The ground stations are licensed as experimental stations by the Federal Communications Commission. The radio frequencies being used are officially assigned to the Department of Defense, but are loaned to NASA for the experiments.

The major experiment is the daily doctor-health aide consultation in the Tanana Service Unit. Each of the participating health aides has a "satellite radio" in her home connected by wire to the nearby ground station. Most health aides are women who speak English well enough to converse easily with the doctor. Every day a doctor at Tanana calls each health aide in turn on the single "party-line" satellite radio circuit. Health aides may ask the doctor for specific instructions after describing signs and symptoms, or may simply verify their own diagnosis and treatment. The medical facilities in the villages are still very limited, so that any serious cases must be evacuated. The satellite radio can then be used to arrange for a plane to evacuate such patients, usually to the Tanana hospital, a 26-bed hospital staffed by two Public Health Service doctors.

The satellite radio is in fact more like a reliable two-way radio than a telephone. At each site with a ground station, users can listen, and participate in the discussions. Although this situation does limit privacy, it also enables the health aides to listen to and learn from the dialogue with other villages.

An interdisciplinary team, drawn from the Medical School, Institute for Communication Research, and the Department of Electrical Engineering at Stanford University, is evaluating the Alaska biomedical communication project under contract with the Lister Hill National Center for Biomedical Communication. With the assistance of Dr. Brian Beattie of the U. S. Public Health Service, they have examined available statistics on the utilization of medical communication facilities and other aspects of health care delivery that might be affected by the use of the satellite radio.

2. Other Uses of the Satellite Radio

Patients at the Alaska Native Medical Center in Anchorage and at Tanana Hospital have talked to their families in the villages via satellite. Previously, the villages may have had no contact with a patient from the time he left for a distant hospital. One health aide commented: "Last year we don't know if they're dead, still in hospital, or what."

ATS-1 has been used experimentally to transmit a lecture from the University of Washington Medical School to a pre-med class in Basic Genetics at the University of Alaska. Dr. Jon Aase delivered the remote lecture with prepared slides, blackboard diagrams, and demonstrations being coordinated with the audio in the University of Alaska classroom. In a questionnaire the students indicated that they preferred to have the lecturer present, but found the audio lecture combined with visual aids preferable to other forms of presentation including delayed time instruction, or independent study. However, they felt the visual component was significant enough to rank two-way television as potentially the best of all possible worlds.

The library of the Alaska Native Medical Center has used ATS-1 for interactive searching of MEDLINE, the National Library of Medicine on-line computer information retrieval service, in Bethesda, Maryland. A computer terminal in Anchorage is connected by satellite to a ground station at Stanford University in California where a connection is made into the TYMNET computer network to reach MEDLINE. In the spring of 1973, this facility was used approximately eight hours a month to link Anchorage and Bethesda.

Two types of doctor-to-doctor communication have been attempted. The doctor on St. Paul, one of the Pribilof Islands in the Bering Sea, regularly consults with specialists in Anchorage via ATS-1. His practice is completely isolated, as radio communication is very unreliable and there is infrequent plane service. During the early months of operation, grand rounds were offered by satellite to the doctors at the Service Unit Hospitals. However, participation was low, and doctors interviewed indicated that the rigid time schedule available for such programs was not compatible with the heavy work load of Public Health Service staff. Some doctors indicated a preference for material available at their convenience in journals and reports or on cassettes.

A separately funded education project produced a poster calling the satellite radio "the radio you can talk back to." Health education programs have been produced by the education project and coordinated by Georgiana Lincoln, Chairman of the Tanana Service Unit Native Health Board. Programs typically are presented by a moderator and expert discussing a topic requested by the villages. Village participants have the opportunity to question the speakers and continue the discussion. Topics have included keeping dogs healthy, presented by a veterinarian and a dog musher, and health education requirements for villages. During the latter program health aides exchanged suggestions for films, posters, and written information for the villages on keeping impetigo sores clean, the importance of well-baby clinics, caring for sick children, building wells and outhouses. "And we don't want any of those films made in California, either!", added one aide.

3. Research Design

In an attempt to isolate the effects of introduction of the new technology from other factors influencing health care delivery in rural Alaska, a quasi-experimental design was imposed on the basic data. A group of nine villages with satellite radios were designated as the "experimental villages." These were Allakaket, Anaktuvuk Pass, Arctic Village, Chalkyitsik, Huslia, Nulato, Ruby, Stevens Village, and Venetie. A tenth village with satellite radio in the Tanana Service Unit, Fort Yukon, was excluded from this analysis because the presence of a nurse and the availability of a telephone made the health care delivery situation in that village quite different from the others.

In order to examine the differences attributable to the satellite radio, statistics were gathered for the year immediately preceding the introduction of the satellite ground stations. Some of the changes from one year to the next might have occurred without the introduction of the satellite radios, however. In order to provide an appropriate baseline for comparison, a group of villages in the Tanana Service

Unit that did not have satellite radios were compared for the same two-year period (using mid-August of 1971, the average date of satellite ground station installation, as the dividing point for the before-after comparison in the "control villages").

4. Communication Contact

The radio logs at Tanana Hospital were examined to determine the frequency of radio contact between Tanana and each of the villages during the two-year period examined. For the 9 experimental villages, the data in Table 1 include the calendar year immediately preceding and the calendar year immediately following the installation in each village. For the 4 control villages (3 others were excluded because there was no record of radio contact with Tanana for 2 years) the radio contact is reported for the year before and the year after the average installation date of August 17, 1971.

TABLE 1

Average Number of Days of Radio Contact per year Before and After Installation of Satellite Ground Stations

(% of possible contact days in parentheses)

	Before Satellite (1970-71)	After Satellite (1971-72)
9 Satellite Villages	51.7 (14%)	270.2 (74%)
4 HF Radio Villages	44 (12%)	24.3 (7%)

During the satellite period, the satellite was not available for 27 days, and the health aides were not required to answer "doctor call" on weekends if they had no patients to discuss. However, in all instances, the percentage of days with radio contact was calculated on the basis of a 365- or 366-day year. The change in radio contact in satellite villages amounts to a more than 400% increase, a difference which is statistically significant despite the small number of villages involved ($t=14.1$, $df=8$, $p<.001$). The drop in the HF villages is not statistically significant, and may be just random fluctuation. If it does represent a real decline, it may represent deteriorating HF maintenance, increasing frustration in using the HF radio when contrasted to the satellite radio, or a decline in the doctors' perseverance in attempting to make contact via HF radio.

The dramatic increase in number of days of contact between the health aides and the doctor is reflected in the increase in the number of medical cases treated. Table 2 compares the number of episodes which the health aides discussed with doctors before and after the installation of the satellite radio. The figure in parentheses indicates the number of episodes per thousand population.

TABLE 2

Average Number of Episodes Treated Before and After Installation of Satellite Ground Stations

(episodes per thousand in parentheses)

	Before Satellite (1970-71)	After Satellite (1971-72)
9 Satellite Villages	47.1 (330)	184.6 (1291)
4 HF Villages	24.7 (286)	15.0 (173)

An episode is defined as a reported illness, accident, or new discussion of a chronic condition. Follow-ups within a few days were not counted.

The data in Tables 1 and 2, while showing dramatic increases in the frequency of contact and the number of new cases treated, do not in themselves demonstrate improved health care. Given the small number of villages involved, all of which have relatively small populations, it is not possible to demonstrate a statistically significant improvement in mortality or morbidity rates. Nevertheless, these statistics do show that health aides can contact a doctor on most days when there is a patient in need of medical attention and that the number of cases treated by public health service doctors has significantly increased. As indicated in the analysis of questionnaires administered to health aides and by the opinions of doctors expressed to the Stanford evaluation team, both health aides and doctors are convinced that the quality of health care has improved. The present documentatation of of the number of cases treated may be the closest we can come to "proof" of improved health as a result of the satellite radio. The only unproved link in the chain of inference is the assumption that diagnosis and treatment over the radio by a Public Health Service doctor results in a better quality of health care in the village than that provided by health aides functioning on the basis of only infrequent contact with a doctor.

5. Health Aide Questionnaire

During the spring and summer of 1972, a questionnaire was administered to health aides in 9 villages with satellite radios and 5 villages with HF radios only. The questionnaire was designed to probe for potential effects of improved communication on village health care. Many of the questions asked the health aides to compare their answers with conditions one year ago, when the satellite radio villages would also have relied exclusively on HF radio. Probes were included frequently to check for the influence of factors other than the improvement in communications. Deliberate effort was made to avoid mention of radio communication in the comparative questions so that the respondents would not attempt to guess the "right" answer.

Daily communication with the doctor was important to the health aides. All 9 of the health aides in satellite villages said that the doctor's directions over the radio were never unclear to them. Seven of the 9 said the quality of reception was less of a problem this year than last. On the other hand, 4 out of 5 health aides in the non-satellite villages indicated that they had difficulty understanding the doctor at least once in a while.

Frequent communication with the doctor seems to increase the health aides' ability to persuade the patients to follow their advice. In 8 of the satellite villages, the health aide felt that people follow instructions most of the time; 2 of the aides with HF radios answered "most of the time" and 3 "some of the time." Three in the HF radio villages and 5 in satellite villages thought this was about the same as last year, but 4 aides in satellite villages felt people followed their advice more often now. Two aides mentioned that patients can now listen to the doctor. One said she kept after her patients more this year. Dr. Beattie comments: "In relating a few of the deaths that occurred in the villages, health aides said that patients or families did not come to see them until the patient was almost dead, or did not return after an initial visit. Follow-up visits are frequently part of the directions given to the health aide over the radio, and better communication should make both the health aide and the patient aware of this importance."

One of the most striking contrasts was in frequency of contact with other health aides, which appears to be very important both for morale and for continued learning. Eight of the 9 health aides in the villages with satellite radio reported that they listen to health aides from other villages talking about their patients with the doctor most of the time. In the non-satellite villages, 2 of the health aides reported that they listened some of the time, and 3 said they never listened.

The health aides were asked to indicate how much they learned from listening to other health aides talking to the doctor. All of the satellite village health aides indicated they learned "quite a lot" or "some," whereas 4 of the 5 in the non-satellite villages felt they learned very little. A more striking difference was the response to the follow-up question: "Can you think of anything in particular you have learned from listening to medical traffic?" Six of the 9 health aides from the satellite villages could name something specific, whereas none of the health aides from the non-satellite villages could think of anything they had learned.

Another striking comparison was in the frequency of contact between the village and patients from the village who are away in the hospital. All 9 of the satellite villages reported that they get news of patients in the hospital most of the time, and all said that they get news more often this year than last. In contrast, in the non-satellite villages, 2 health aides said they heard most of the time, 2 some of the time, and 1 almost never. Four of the 5 said this was about the same frequency as last year.

For some aspects of the health aides' work, communication seems to be one of several influential factors. For example, 7 of the 9 health aides from satellite villages and 4 from non-satellite villages felt more confident in their work this year than last year. Contact with a doctor was the most frequently cited reason.

6. Hospital Admission Records

One possible effect of improved medical communication is a change in the number of hospitalizations. Unfortunately, it would be possible to rationalize changes in either direction. Improved communication could result in transportation being arranged more quickly and more patients getting to the hospital who wouldn't otherwise. Improved medical care thus could mean more, rather than fewer, hospitalizations. On the other hand, improved medical care in the villages may result in fewer cases progressing to the point where hospitalization is necessary. Or the knowledge that reliable communication is available to discuss cases with a doctor may result in fewer hospitalizations in marginal cases.

Although interpretation of results must amount to post hoc explanation rather than hypothesis testing, hospital admission records were examined at the four major hospitals serving patients from the Tanana district: the Tanana Hospital, the Alaska Native Medical Center in Anchorage, and Fairbanks Memorial and Bassett Army Hospital in Fairbanks. Following the quasi-experimental design of before-after comparisons with a control group, hospital admissions of patients from the 9 experimental villages were compared with hospital admissions from 7 control (non-satellite) villages for the year preceding and the year following introduction of the satellite communication system.

The number of hospital admissions from satellite villages declined by about 2.5 patients per village per year (from 38.6 to 36.1) while the number of hospital admissions from non-satellite villages was increasing by about the same amount (from 13.7 to 16.4). This difference is not statistically significant, given the small number of cases on which these statistics were calculated. If the trend turns out to be consistent, then a claim could be made that the satellite communication system has the potential of saving health dollars by reducing the number of hospitalizations.

7. Types of Cases Treated by Radio

From the radio logs at the Tanana hospital it was also possible to obtain a crude indication of the kinds of cases treated by radio. The variation is considerable, and it was not always possible to code reliably from the brief data in the radio log; consequently, the number of cases coded into the "other" category is considerable. Nevertheless, the data presented in Table 3 provide a general indication of the kinds of cases treated via satellite radio and by HF radio.

8. Future Plans

Use of the experimental satellite communication system is continuing on a daily basis in the Tanana Service Unit of the Alaska Area Native Health Service. In April of 1974 a new experimental satellite, ATS-F, will be launched by NASA. That will permit nearly a year of experimentation with two-way video teleconsultation services from remote medical facilities at Fort Yukon and Galena to doctors at Tanana and Fairbanks. Fort Yukon and Galena are local transportation centers. It is planned to use ATS-1 voice communication for scheduling of ATS-F video consultations, including arranging for patient travel from outlying communities to Galena and Fort Yukon. ATS-1 will also be used for data communication to permit on-line retrieval of problem-oriented medical records of Tanana Service Unit patients from an Indian Health Service computer in Tucson, Arizona. Continued use of

Table 3

Cases Treated by Satellite Radio in the First Year of Operation (Approximately mid-August 1971 through mid-August 1972), by HF Radio in the Year Previous. and by HF Radio since Satellite Installation (Control Group).

Disease or Symptom	HF Radio (1970-71)		HF Radio (1971-72)		Satellite (1971-72)	
	Number	Percent	Number	Percent	Number	Percent
Sore Throat	51	9.8%	1	1.3%	114	6.9
Flu or Upper Respiratory Infection	27	5.2	5	6.4	99	6.0
Abdominal Pain	13	2.5	6	7.7	90	5.4
Urinary Infection	18	3.5	2	2.6	44	2.6
Ear Problem	83	16.0	9	11.5	198	11.9
Diarrhea	8	1.5	1	1.3	60	3.6
Lacerations	21	4.0	5	6.4	71	4.3
Tooth Problems	35	6.7	5	6.4	51	3.1
Chest Pain	22	4.2	2	2.6	40	2.4
Pneumonia	14	2.7	8	10.3	69	4.2
Skin Infections	41	7.9	6	7.7	115	6.9
Rash (non-specific dermatitis)	15	2.9	5	6.4	117	7.0
Other	171	32.9	23	29.5	593	35.7
TOTAL	519	99.8	78	100.1	1,661	100.0

ATS-1 capability in other Tanana Service Unit communities will be essential to provide an audio-only control comparison for the video teleconsultation experiments.

9. Discussion

The health aides and physicians in the Tanana Service Unit have accepted the ATS-1 satellite capability as an integral part of their on-going health care delivery system. The regional native association, The Tanana Chiefs, has requested that additional ATS-1 ground stations be installed in communities still lacking reliable voice communication. The HF radio system for medical communication in the region has fallen into disuse. As long as the experimentation continues, the native peoples of the region are benefitting from the improved quality of health care.

The apparent success of the ATS-1 medical communication experiments leaves the sponsors of the experiment and the Indian Health Service with a severe moral problem. It would be cruel to terminate the experiments without providing a replacement communication system that can at least provide a way for the people in remote communities to contact a doctor. But technical failure of the old (1966) satellite is certain to come at some point, even if the pressures to terminate the series of experiments before satellite failure are successfully resisted. In the opinion of some observers, satellite failure or administrative termination could have the same effect of leaving the health care communication system in a worse state than it was before the experiment, while the native communities have been given much higher expectations concerning appropriate standards of service.

The major recommendation of the ATS-1 evaluation is that the Indian Health Service, possibly in conjunction with the sponsors of the experiments it has permitted in their health care system, should undertake a planning study to determine the most cost-effective way of providing an operational system for health communication in Alaska. Such an operational system might serve other remote and isolated areas in Alaska in addition to those now benefitting from experimental service. It could be based on a combination of terrestrial links and satellite links utilizing services from one of the several U. S. domestic satellite companies now in existence.

ATTACHMENT XI.6

SPECIFICATIONS FOR A SMALL SATELLITE COMMUNICATIONS EARTH STATION

1.0 INTRODUCTION

This document establishes the specifications for a small satellite communications earth station (ES) intended for simplex message service in a multi-station communications network. The ES provides frequency modulation and frequency translation from voice frequency (VF) to RF on the transmit side and provides frequency translation from RF to VF including demodulation on the receive side. The equipment shall perform the functions of VF processing (compandor), modulation, carrier frequency change, up and down conversion, and demodulation.

The ES transmissions shall be controlled by a push-to-talk switch. Frequency control shall be by means of a self-contained, 5 MHz, high-stability reference oscillator. All carrier and conversion frequencies used in the ES equipment shall be referenced to this oscillator.

The ES equipment shall be capable of duplex operation (although only simplex operation will be used initially). It shall be possible to equip the station to permit independent choice of up to 5 transmit and 5 receive frequencies.

2.0 APPLICABLE DOCUMENTS

The following documents are part of this specification to the extent stated herein. The technical documents are listed in order of precedence, this specification having the highest precedence.

a) Statement of Work for ES equipment

3.0 CONFIGURATION

3.1 SYSTEM

The satellite communication network consists of a number of earth terminals interconnected by the satellite such that any terminal can communicate with any other through the satellite. In its simplest form all stations in the network transmit on the same frequency and receive on the same frequency in a party-line type of operation. One station, designated as the master station, provides the network control and directs the remote stations in their operations. Each station is equipped with the capability of preempting the system operation in an emergency. Frequency modulation shall be used.

3.2 EARTH STATION EQUIPMENT

The functional configuration of the ES equipment shall be as shown in Figure 1. The transmit equipment shall accept VF inputs, provide VF processing, carrier generation and modulation, and a modulated RF output at the designated frequency in the 5925- to 6425-MHz range. The receive equipment accepts input signals in the 3700- to 4200-MHz range, and provides demodulation and VF processing to obtain a VF output.

The equipment shall be designed to accept alternately a 4-wire telephone line input/output or a local microphone and speaker with the option that earphones may be used instead of the speaker.

3.3 LOCATION OF MAJOR SUBASSEMBLIES

The antenna is to be located in an outside environment which may be up to 100 ft. from the transmit and receive portions of the station. The low noise transistor amplifier is to be located on the antenna feed as close to the

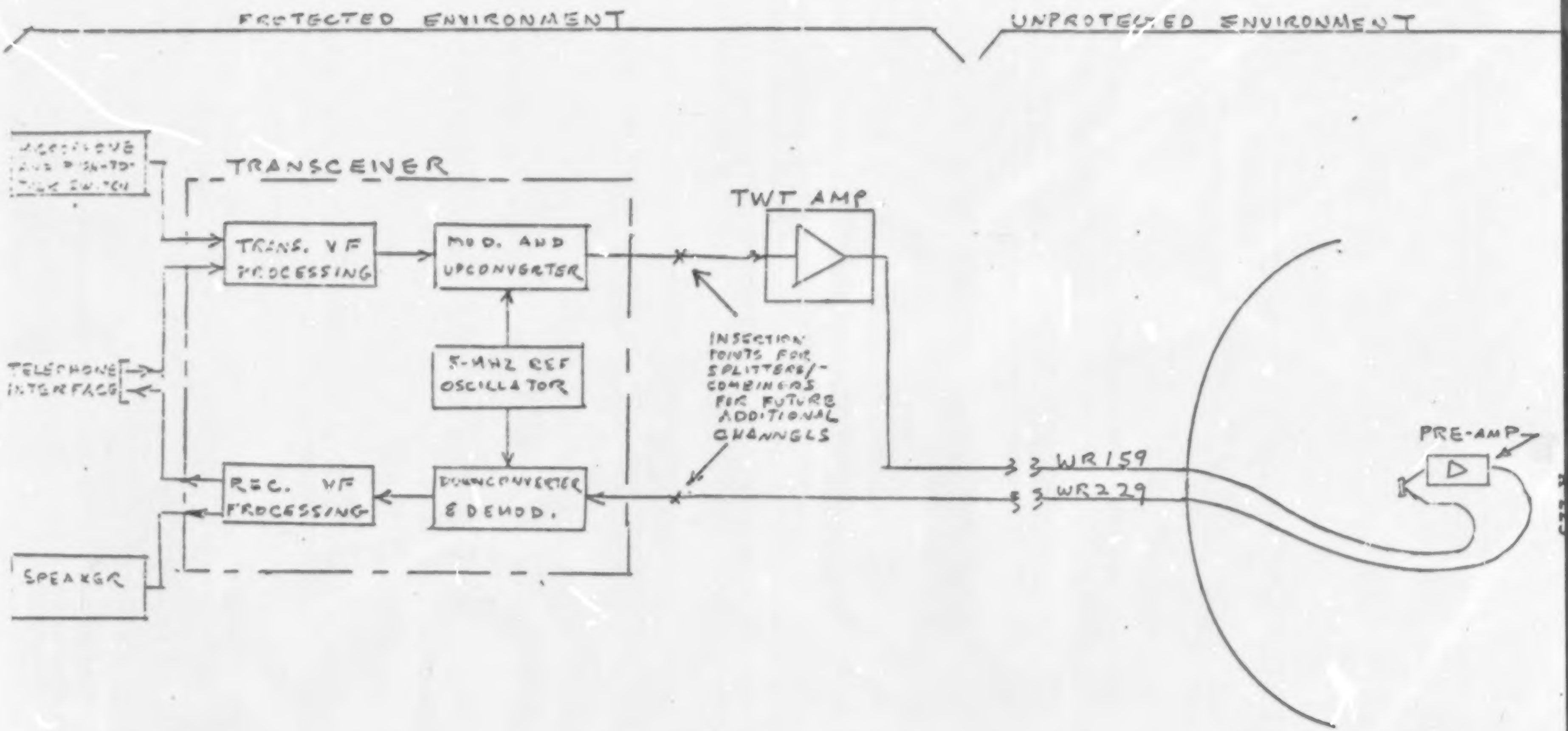

PROTECTED ENVIRONMENT
UNPROTECTED ENVIRONMENT
MICROPHONE AND PUSH-TO-TALK SWITCH
TRANSCEIVER
TRANS. VF PROCESSING
MOD. AND UPCONVERTER
5-MHZ REF OSCILLATOR
DOWNCONVERTER & DEMOD.
REC. VF PROCESSING
TELEPHONE INTERFACE
SPEAKER
TWT AMP
INSECTION POINTS FOR SPLITTERS/-COMBINERS FOR FUTURE ADDITIONAL CHANNELS
WR159
WR229
PRE-AMP

FIGURE 1.

BLOCK DIAGRAM

feedpoint as possible. The interconnection between antenna/preamplifier and the other equipment is to be by means of waveguide except, that in the case of a very short distance, coaxial cable may be used between the preamplifier and the remainder of the receive equipment. All waveguides and air dielectric cables shall be pressurized with dry air.

The low power transmit equipment and the receiving equipment and the transmit TWT amplifier are to be in the same enclosure and will be in a protected environment.

4.0 PERFORMANCE REQUIREMENTS

This section contains the pertinent performance characteristics of the ES equipment as well as its electrical interfaces. Performance requirements are subdivided into six categories, namely: general, transmit, receive, looped, compandor, and interfaces. Because of the difficulty of measuring some of the performance characteristics when the compandor is included, the looped parameters apply to a non-compandored condition unless otherwise indicated. These parameters can be measured quantitatively. The compandor characteristics listed are derived from the applicable sections of CCITT Recommendation G162.

4.1 GENERAL

4.1.1 Radio Frequency Allocation

The transmit and receive operating frequencies will generally be 2225 MHz apart. The exact frequencies will be supplied at the time an order is placed.

4.1.2 Operational Receive Flux Density: -156 dBw/m^2. Under this condition the minimum uncompandored test-tone-to-noise ratio (TT/N) is 32 dB, unweighted, including preemphasis.

4.1.3 Degraded Receive Flux Density: -158.4 dBw/m^2. Under this condition the minimum uncompandored TT/N is 20 dB, unweighted, including preemphasis.

4.1.4 Channel Plan

Each ES equipment is to be designed so that it may eventually be switched to any one of up to 5 preselected frequencies. These RF channels will be spaced 25 kHz center-to-center and will all lie within a 200-kHz band. (Note that this band will support 8 channels, but it is not the intention that the equipment be made to be switchable to more than any 5 of these 8.) The selection of frequencies in the transmit and receive directions are to be independent of each other, although, in general, the centers of the 200 kHz wide bands will be different by 2225 MHz.

4.1.5 Type of Operation

The operational system for which this equipment is designed may be either simplex (communicating stations transmit alternately on the same frequency) or duplex (communicating stations transmit simultaneously on different frequencies).

4.1.6 Emphasis

Emphasis shall be provided across the 300-3400 Hz transmit voice band following compression. This emphasis shall be 6 dB/octave. Complementary de-emphasis shall be provided in the receive equipment preceding the expander.

4.2 TRANSMIT

4.2.1 Frequency

The transmit carrier frequency will be in the band 5925- to 6425 MHz. The exact frequencies for which the equipment is to be furnished will be supplied at the time an equipment order is placed.

4.2.2 Stability

The transmit carrier is to be referenced to a high stability 5 MHz oscillator. The transmit carrier shall have the same stability as this reference oscillator. They require stability of better than 1×10^{-8}/day and 5×10^{-8}/month. Means shall be provided for easy access to the tuning adjustment on the oscillator to permit periodic resetting of the precise oscillator frequency.

4.2.3 Occupied Bandwidth

The modulated transmit carrier shall be contained in a band not to exceed 21 kHz. Over deviation protection shall be included in the transmitter to prevent emissions outside of this band.

4.2.4 Spurious Outputs

The specified 25 kHz band shall contain 99% of the radiated power. No discrete signal shall exist outside of this band which contains more than 0.25% of the total radiated power. The mean power of omissions shall be attenuated below the mean output power in the 25 kHz band in accordance with the following schedule.

(1) from 12.5 kHz to 25 kHz away from the center frequency: at least 25 decibels;

(2) from 25 kHz to 62.5 kHz away from the center frequency: at least 35 decibels;

(3) greater than 62.5 kHz away from the center frequency: at least 43 plus 10 Log_{10} (mean output power in watts) decibels or 80 decibels, whichever is the lesser attenuation.

4.2.5 Deviation

4.2.5.1 Telephone Test Tone

The peak-to-peak deviation of a 1 kHz test tone of -5 dBm0 level applied at the telephone interface as described in Section 4.6.3 shall be 10.1 kHz.

4.2.5.2 Microphone

When the microphone is used, the VF gain shall be adjustable so that modulation peaks will cause a peak-to-peak deviation of 18 kHz.

4.2.6 Push-to-Talk Operation

A switch is to be included with a microphone which will control the transmit carrier such that when the switch is in the off position, the transmit level will be at least 50 dB lower than when the switch is in the on position. Circuitry shall be provided to limit any single push/talk time to 3 minutes without recycling (disengaging the push-to-talk switch and then re-engaging the push-to-talk switch).

4.2.7 Preemption Capability

A preemption switch shall be included on the panel of the transmit equipment which shall provide modulation of the carrier at full deviation by 2 tones. These 2 tones are to be of equal level, their use being intended to prevent accidental triggering of preemption detectors by voice modulation.

4.3 RECEIVE

4.3.1 Noise Figure of Equipment

The noise figure of the electronic equipment shall be such as to achieve the desired test tone-to-noise ratios with the RF flux densities specified in Sections 4.1.2 and 4.1.3. In no case, however, shall the noise figure of the equipment be greater than 5 dB when measured at the interface between the antenna feed and the transistor preamplifier.

4.3.2 Noise Bandwidth

Noise bandwidth of the receive equipment shall be 21 ±0.5 kHz.

4.3.3 Spurious Responses

The equipment shall not respond in a measurable fashion to any other signals which may be present in the satellite. Adequate filtering must be provided to insure against interference from adjacent RF channels (spaced as closely as 25 kHz) or from other satellite signals outside of the nominal 200 kHz bandwidth. The receive equipment shall not be degraded in the presence of the 6 GHz transmit carrier, since the equipment may alternately be used in full-duplex operation.

4.3.4 Receive Preemption

The receive side of the earth station equipment shall include two VF filters with appropriate detectors and logic so that reception of high level tones on those two frequencies will cause a red light to appear on the front panel of the equipment. In addition, a buzzer or other audible alarm will be sounded when these two high-level tones are being received simultaneously.

4.4 COMPANDOR

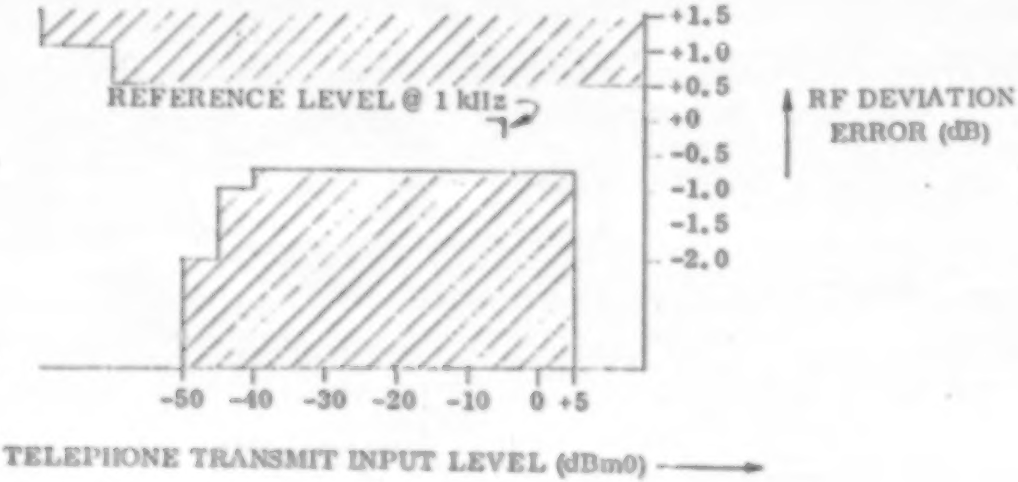
4.4.1 Definition and Value of the "Unaffected Level"

The unaffected level is the RF deviation which remains unchanged whether the circuit is operated with or without the compandor. The unaffected level shall be -5 dBm0 at the telephone interface corresponding to a peak-to-peak RF deviation of 10.1 kHz when the modulating signal is a 1000 Hz tone.

4.4.2 Ratio of Compression and Expansion

4.4.2.1 Compression Ratio

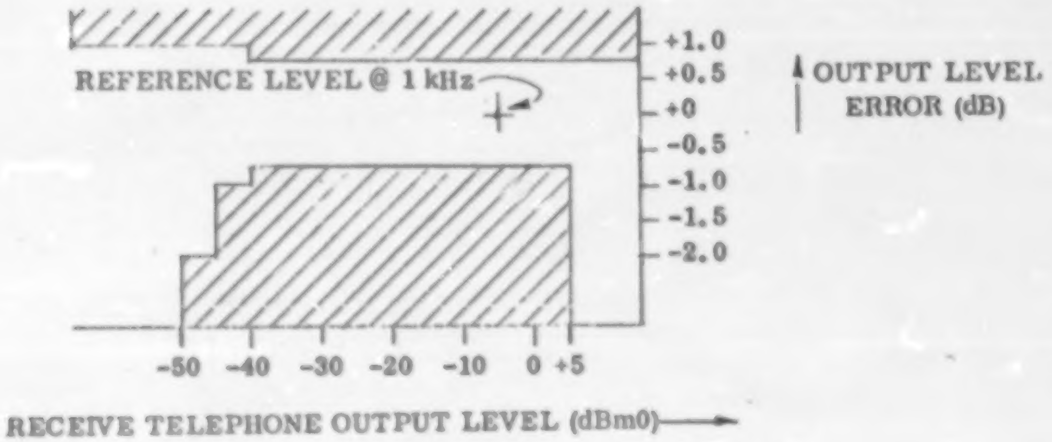
The ratio of RF deviation change to input signal level change shall be +0.5 dB/dB. Departure from the transfer characteristic having this ratio, referenced at -5 dBm0, 1 kHz, shall fall within the limits shown in Figure 2.



The upper limit shall apply for modulation rates between 200 and 4000 Hz, the lower limit between 300 and 3400 Hz.

4.4.2.2 Expansion Ratio

The ratio of the receiver output level change to RF input deviation change shall be +2 dB/dB. Departure from the transfer characteristic having this ratio, referenced to -5 dBm0, shall fall within the limits shown in Figure 3 for modulation frequencies between 300 Hz and 3400 Hz.



4.4.3 Transient Response

4.4.3.1 End-to-End Transient Distortion

The receiver output overshoot (positive or negative) shall be less than ±20% when a 2 kHz transmitter input signal level is switched between -4 dBm0 and -16 dBm0 in either direction.

4.4.3.2 Compressor Attach and Recovery Times

4.4.3.2.1 Compressor Attack Time

The RF deviation shall settle to within 1.5 times its steady state value in 5 ms or less when a 2 kHz transmitter input signal is switched from -16 dBm0 to -4 dBm0.

4.4.3.2.2 Compressor Recovery Time

The RF deviation shall settle to 0.75 times its steady state value in 22.5 milliseconds ±20% when a 2 kHz transmitter input signal is switched from -4 dBm0 to -16 dBm0.

4.5 PERFORMANCE

An RF-to-RF loop through a test translator is implied in the following performance requirements unless otherwise specified.

4.5.1 Voice Frequency Response (with compandor): ±1 dB 400-3000 Hz
+1 -3 dB 300-3400 Hz

4.5.2 Impulse Noise (non-compandored)

With an input level corresponding to the nominal receive flux density of Section 4.1.2, the VF output shall have an impulse count which does not exceed __________ impulses per 30 minutes above a level of - ________ dBm0. [Bidder to specify performance]

4.5.3 Harmonic Distortion (with compandor)

With an input 1000 Hz test tone which produces an RF output of 6 kHz peak-to-peak, the harmonic distortion of the received VF output shall not exceed 2 percent. This distortion shall include the rms addition of both 2000 and 3000 Hz components.

4.6 ELECTRICAL INTERFACES

4.6.1 Transmit (RF)

a. EIRP. The effective isotropic radiated power of the station to the satellite shall be not less than $56.8 + 20 \log \frac{f_{Tx}}{6000}$ dBw over the range from 5925 to 6425 MHz. This EIRP is the summation of the output power of the TWT amplifier and the antenna gain at the transmit frequency less the interconnecting waveguide losses. This requirement is for any frequency in the 5925- to 6425 MHz band.

b. Transmit amplifier output power. The TWT amplifier must provide enough output power to meet the required EIRPs. In no case, however, shall the maximum power at the output flange of the TWT amplifier be less than 30 watts when at full output power at any frequency in the 5925- to 6425 MHz band.

c. Antenna Gain. The antenna must have adequate gain to meet the EIRP requirement. In no case, however, shall the gain be less than $43.0 + 20 \log_{10} \frac{f_{Tx}}{6000}$ dBi across the 5925- to 6425 MHz band.

d. Polarization. The transmit polarization is to be linear, with a cross polarization less than -25 dB over the 3 dB beamwidth. The feed is to be mounted in such a way that the polarization can be set at any angle with respect to the local horizontal.

4.6.2 Receive (RF)

a. Receive Level. The receive flux density is that nominal value specified in Section 4.1.2.

b. Dynamic Range. The receive flux density may vary ±5 dB from the nominal value.

c. The frequency range will be 3700- to 4200 MHz.

d. Antenna Gain. The antenna must have adequate gain to meet the TT/N versus flux density requirements. In no case shall the antenna gain be less than $39.5 + 20 \log_{10} \frac{f_R}{4000}$ dBi over the band from 3700- to 4700 MHz.

e. Polarization. The receive polarization is to be linear and positioned at right angles to the transmit polarization. It is to have a cross polarization less than -25 dB over the 3 dB beamwidth. The receive polarization is to remain at right angles to the transmit polarization as the feed is set at any angle with respect to the local horizontal.

f. Isolation. The antenna is to provide at least 25 dB isolation between the transmit feed connector and the receive feed connector.

4.6.3 VF (Telephone)

a. Impedance. The transmit and receive impedances shall be 600 ohms with return loss greater than 20 dB between 300 and 3400 Hz.

b. Transmit Level. The equipment shall be capable of accepting any telephone transmission levels between 0 and -16 dBr.

c. Receive Level. The equipment shall be capable of delivering any receive transmission level between 0 and +10 dBr.

4.6.4 Frequency Control

Frequencies of all oscillators used in the equipment shall be referenced to the 5 MHz station reference. The exact receive frequency shall be capable of being adjusted ±25 kHz in 500 Hz steps from its nominal value to account for drifts in the satellite transponder oscillator. It shall be possible to make this adjustment by transmitting the signal to the satellite and making the adjustment while watching an internal meter on the equipment. Regardless of the setting of the adjustment for compensating for satellite transmission oscillator drift, the oscillators in the receiver shall be referenced to the 5 MHz oscillator. The periodic readjustment of the exact receive frequency shall not require any external test equipment.

4.6.6 Antenna Pattern Requirement

In addition to the gain required to meet the performance limitation, the antenna is to meet the following sidelobe specifications. Note that there are two specifications; high performance and regular. Bidders may respond to either or both specifications. If they respond to both, they should indicate the price difference between the two options.

a. Regular. Outside the main beam, the gain of the antenna shall lie below the envelope defined by:

$32 - 25 \log_{10}(\theta)$ dB: $1^\circ \leq \theta \leq 19^\circ$

0 dBi $19^\circ < \theta \leq 180^\circ$

b. High Performance

$32 - 25 \log_{10}(\theta)$ dBi: $1^\circ \leq \theta \leq 48^\circ$

-10 dBi: $48 < \theta \leq 180^\circ$

where θ is the angle in degrees from the axis of the main lobe, and dBi refers to dB relative to an isotropic radiator. For the purposes of this section, the peak gain of an individual sidelobe may be reduced by averaging its peak level with the peaks of the nearest sidelobes on either side, or with the peaks of two nearest sidelobes on either side, provided that the level of no individual sidelobe exceeds the gain envelope given above by more than 6 dB.

4.7 ALARMS AND CONTROLS

4.7.1 Loss of Transmit Phase Lock

The transmit carrier shall automatically be turned off in the case of any loss of phase lock in a phase-locked loop used to reference the transmit carrier to the 5 MHz oscillator. Loss of any phase lock transmit or receive shall cause a red lamp to glow on the front of the equipment.

4.7.2 Remote Meter

A meter whose reading corresponds to received carrier level shall be provided external to the electronic equipment with wire installed in place so that the meter can be used at the antenna for aligning the antenna to the satellite.

4.7.3 Deviation Warning

A lamp shall be included on the front panel of the transmit equipment to indicate excessively high input voice levels which would result in distortion in the over-deviation prevention circuits.

5.0 OPERATIONAL REQUIREMENTS

The satellite local oscillator drift must be capable of being corrected in the operational system as described above in Section 4.6.5. The frequency of this adjustment is expected to be no more often than every 3 months and the simplicity of these adjustments is of critical importance in the design of the station since it is expected that this drift correction will be made by non-technical personnel, perhaps while being guided through the communications link by the master station.

It shall be possible using the master station as a reference to check the accuracy of each local 5 MHz reference. It shall be possible to adjust the reference at the station without the use of external test equipment and the means for doing this shall be included in the equipment design.

The equipment shall include a preemption capability as described above in Sections 4.2.7 and 4.3.4. The purpose of this preemption capability is to allow any station to interrupt traffic which is being transmitted and, by this means, to provide for emergency service even though the simplex channel is in use at the time that the emergency arises.

6.0 RELIABILITY

The equipment shall be designed with the following objectives:

a. The stations will generally be operated by non-technical personnel and equipment failure will result in a loss of communications to the community served by the station. It is incumbent, therefore, that a conservative equipment design be used and that the equipment be of high quality workmanship and use high quality components throughout.

b. Maintenance will be by means of replacing equipment subassemblies, that is, by complete replacement of the transistor preamplifier, transceiver equipment, or the TWT amplifier. Internal metering shall be provided to permit ready identification, where feasible, of the failed subassembly.

c. Repair of major subassemblies will be done in a central depot where technically competent personnel and suitable test equipment will be located. The design shall, where possible, permit this depot repair of the respective subassemblies.

d. Attention of the bidder is drawn to the warranty requirements of the Statement of Work.

7.0 MECHANICAL REQUIREMENTS

7.1 GENERAL

The ES equipment shall be mounted in an attractive cabinet whose overall dimensions shall be the minimum required for the equipment. Interconnecting cables and waveguides among the subassemblies shall be suitable for installation in an environment which does not provide full mechanical protection to the cables and waveguide. A mechanically-rugged approach is desirable. No rotating equipment (such as fans) shall be used in the design of the ES equipment.

7.2 FINISH

The final finish on front panels shall be a gray semi-gloss enamel with black silkscreen markings.

7.3 SIZE

7.3.1 Transistor Preamplifier

The transistor preamplifier is to mount at the antenna in the environment specified below in Section 8.1. It is anticipated that oven-heating will be required for the transistor amplifier.

7.3.2 Transceiver and TWT Amplifier

The transceiver and transmit TWT amplifier are to be in a cabinet in a protected environment.

8.0 ENVIRONMENTAL REQUIREMENTS

8.1 EQUIPMENT WITHOUT ENVIRONMENTAL PROTECTION

The equipment mounted outside of the building shall be able to operate to specification in ambient temperatures of -60°C to +50°C. This includes the antenna, transistor preamplifier, and interconnecting cables and waveguide. This equipment shall be capable of withstanding temperatures from -60°C to +60°C in a non-operating condition without damage.

8.2 ANTENNA ENVIRONMENTAL SPECIFICATIONS

The antenna is to maintain its normal performance with winds up to 45 mph, up to 1/4 inch radial ice, and up to 4 inches vertical snow fall.

The antenna degradation in transmit gain and receive gain (including surface distortion and pointing error) is to be less than 4 dB with winds up to 85 mph, up to 1/2 in radial ice and up to 6 inches vertical snow fall.

The antenna is to survive with no permanent deformation with winds up to 120 mph, up to 1 inch radial ice, and up to 12 inches vertical snow.

8.3 PROTECTED EQUIPMENT

Equipment which is intended for operations within a sheltered environment (the transceiver and power amplifier) shall be capable of operating between temperatures of 0 and 50°C without performance degradation. This equipment shall also be capable of withstanding temperatures between -60°C and +60°C in a non-operational condition without damage. This equipment shall operate satisfactorily in a relative humidity of up to 95% at temperatures to 35°C.

9.0 POWER

The ES equipment shall be designed to operate from dc voltages between -21 and -32 Volts (positive ground). In a non-transmit (i.e., idle) condition, the current drain of the ES equipment shall be less than 2 amperes; in a transmit condition the current drain shall be less than 10 amperes. The equipment shall be capable of operation over the entire dc voltage range without readjustment by the operator while meeting all of its performance specifications.

10.0 TEST PROGRAM

10.1 GENERAL

This section lists tests which are to be performed in the factory prior to shipment. The tests denoted by an asterisk are those which need be performed on the first deliverable unit only. These tests may be deleted from subsequent units providing the first unit passed the indicated tests with no difficulty or rework.

10.2 PARAMETERS TO BE TESTED

10.2.1 Transmit

a. Frequency Stability*
b. Occupied Bandwidth
c. Overdeviation Protection
d. Spurious Outputs*
e. Telephone Deviation
f. Voice Deviation
g. Push-to-Talk Operation
h. Preemption Capability

10.2.2 Receive

a. Noise Figure

b. Noise Bandwidth

c. Spurious Responses.

d. Operational Receive Flux Density Test-Tone-to-Noise Ratio

e. Degraded Receive Flux Density Test-Tone-to-Noise Ratio

f. Preemption Capability

10.2.3 Loop Tests

a. Voice Frequency Response

b. Impulse Noise.

c. Harmonic Distortion

d. Compandor Unaffected Level

e. Compandor Compression Ratio (over the range of levels)

f. Compandor Expander Ratio (over the range of levels)

g. Compandor Variation of Compressor Gain.

h. Compandor Variation of Expander Gain.

i. Compandor Transient Response.

10.2.4 Electrical Interfaces

a. EIRP Capability

b. Telephone Interface Impedance.

c. Telephone Transmit Level.

d. Transmit Receive Level Interface.

e. Modulation With Microphone

f. Speaker Volume

g. Frequency Control

h. Alarms and Controls

i. Remote Receive Carrier Level Meter

j. Deviation Warning

10.2.5 Workmanship

All equipments will be inspected for quality of workmanship and construction.

10.2.6 Mechanical

a. Finishes

b. Size*

c. Weight*

10.2.7 Environmental

The first unit produced will be fully environmentally tested to demonstrate compliance with requirements of Section 8 of the specification. Where this is not practical with the antenna, the bidder is to describe those tests he proposes to demonstrate in compliance with the specification.

10.2.8 Power

The first unit produced shall be checked across the range of voltages specified in Section 9 to insure proper operation across the total voltage range. This same first unit will be checked for idle and transmit current drains on the battery system.

11.0 DOCUMENTATION

Documentation will be of two types: (1) an operations instruction manual intended for the non-technical station operator, and (2) a maintenance manual for the depot maintenance personnel.

11.1 OPERATIONS MANUAL

This manual will give, in non-technical terms, instructions for operation of the equipment. It will include alignment instructions for the antenna and instructions for use of the various controls, meters, and alarms on the equipment. The instructions shall be in a step-by-step form with illustrations to augment the verbal instruction.

11.2 MAINTENANCE MANUAL

A complete maintenance manual shall be available as a part of the ES equipment. This manual shall be geared to the level of a trained technician, not to that of a graduate engineer. The manual shall include a technical description of the equipment including theory of operation of the overall equipment and of each of the separate subassemblies which make up the earth station. Line-up instructions shall be included in the manual, including instructions on how to tune frequency sensitive elements unless the tuning requires expensive jigs and/or test equipment which make field tuning impractical. A section of the manual shall be dedicated to troubleshooting the earth station equipment and shall include special instructions as may be necessary in the repair or adjustment of the equipment.

The manual shall include both block and level diagrams as a part of the theory of operation of the equipment and detailed schematic diagrams complete with parts lists. Component markings on the parts of the earth station equipment shall agree with those on the schematics and shall be arranged in orderly fashion to permit ready identification of the part. Standard markings shall be used throughout in accordance with ASME/IEEE US Standard Y32.16-1968.

The maintenance manual shall include a list of required test equipment described in terms of functional requirements as well as suitable equipment by manufacturer and type number. The manual shall also include a listing of any special tools or jigs required for testing and/or maintenance of the equipment.

11.3 SPARE PARTS LIST

List of recommended spare parts for 6 months and for 12 months maintenance levels shall be furnished as a part of the earth station procurement.

ATTACHMENT XI.7

Central Manual Telephone Exchange

There are several simple methods of implementing a manual telephone exchange at a cost small compared with the cost of the stations in the remote communities. The final choice of method depends on the sequence of station installations, the number of calls originating from each phone, the type of service desired and the destinations of the calls.

For service to the Alaskan villages there would be one telephone installed in each of the 120 villages not now having phone service. To serve these 120 telephones, RCA has estimated approximately 25 satellite circuits would be needed. The 25 circuits would come to one or more central exchanges where an operator would connect the calls through existing ground lines to the destinations.

The simplest approach may be the most desirable in view of the need. It would be simplest to have one exchange, most likely in Anchorage. In the exchange four or five village telephones would be permanently assigned to each of the 25 circuits. The 25-circuit, bush phone service would be operated manually by one or two operators in the Anchorage bush phone exchange.

To call a village a caller would dial the Anchorage exchange. If one of the four or five villages was using the line, the operator would report "line busy" to the caller. Otherwise the operator would transmit one of five standard tone sets to ring the phone in the desired village. When the phone in the village is picked up the circuit is completed. If the phone is not picked up (the station may be in use for medical communications) the operator would report "no answer" to the caller.

When the circuit is in use, power in the circuit from the exchange to the village provides an "in use" signal to the other three or four villages on the same circuit. This signal is used in these villages to lock out the telephone and give a busy signal, when the telephone is picked up. To make a call from the village, the caller picks up the telephone; if the line is not busy his station automatically begins transmitting to the Anchorage exchange, where the operator answers and dials the desired number.

To call a village on the same satellite circuit the operator requests the caller to select line two on his phone. This adjusts the station to transmit and receive on the frequencies appropriate for direct telephone conversation with the other village.

The station designed for the Indian Health Service has the equipment in it for this exchange alternative. The costs above those already included in the estimates, is the 25-circuit switchboard, rental of 25 voice circuits from the RCA Anchorage ground station to the switchboard, the 25 channel electronics at $5,000 or less per channel at the central exchange, and 24 hour manning of the switchboard. The operator cost would dominate the switchboard cost and is estimated by RCA to be $65,000 per year.

It is clear that the central switchboard is a small simple operation and will not be a major cost factor in the program.

Questions have arisen about the grade of service, the probability of a line being free when it is wanted. Although we tend to agree with estimates that 25 lines for 120 telephones is adequate; if more are desired, more could be acquired from the satellite.

A more complicated technique would assign groups of circuits to groups of villages, three circuits to 15 villages for example. This would somewhat improve the probability of having a free line during the busiest part of the day but add the requirement of line selector equipment at each village. This seems to be an unwarranted choice in that the improvement is small. When the traffic increases to warrant more than one phone per village, then such techniques should be considered to make better use of satellite channels.

ATTACHMENT XI.8

ALASKAN INDIAN HEALTH SERVICE SATELLITE COMMUNICATION STATION

BASIC STATION CONFIGURATION

The "Basic" station refers to the configuration that would be installed initially in each village and field hospital to meet health service needs. The "Basic" station includes features that allow easy future addition of optional equipment to meet expanded service needs. The basic station has the following characteristics:

I. Single Receive and Transmit Channels

The station is to have one transmit channel (modulator, frequency synthesizer, up converter, and power amplifier), and one receive channel (preamplifier, down converter, and demodulator).

II. Frequency Agility

The transmit and receive frequencies are to be digitally controllable. They are to be capable of being set to at least 50 adjacent channel positions. Transmit and receive are to be controlled independently of each other. Settling time in switching from one channel to another two positions away should be less than 100 milliseconds; switching to fifty channel positions away may have a settling time up to 500 milliseconds.

The above agility requirements are to accommodate the optional addition of an automated direct dial telephone system. In the "Basic" station configuration for remote villages, the control digits will be hardwired to a predetermined transmit and corresponding receive channel for simplex operation. The "Basic" stations at the field hospitals will have a manual switch to select between five predetermined transmit and corresponding receive channels for simplex operation.

III. Adjustment for Drift in Satellite Offset

The frequency difference between transmit and receive channels is to be adjusted manually to compensate for long term aging in the satellite offset standard. Change in the satellite offset frequency is to be determined centrally. Periodically, personnel at the remote locations will be asked to turn a dial to a new setting to compensate for the satellite drift.

Short term satellite offset drift, which occurs as the satellite passes through the earth's shadow, at the equinoxes, will if necessary be compensated for manually at the central field hospital stations by temporarily reducing the modulation index and adjusting the receive frequency. This will result in at worse a reduction of signal quality for several late night hours on several days twice a year.

IV. Transmitter Power

The transmitter will have a power level, (30 watts), that will enable one remote station to talk directly with another remote station. This will provide the normal service for the health uses.

As an option, the drive level to the transmitter may be reduced to obtain lower power, (~1 watt), from the transmitter. This level is suitable to transmit to a larger central station or directly to other small stations on a future satellite with proper transponder gain. At this level, up to six additional channels could be used simultaneously without changing the transmitter.

V. Baseband Processing

The channelizing equipment is to deliver a quality voice signal with a carrier to noise, C/kT, of 52 dbw/°k, in a bandwidth of 20,000 Hz. The equipment is to have voice-activated carriers and the equivalent of echo suppression for duplex operation. In the "Basic" configuration the station will be set for simplex operation and speaker and microphone are to be provided for push-to-talk use. The village stations are to be equipped with an emergency alarm button that when pushed will trip an "emergency" indication circuit in the field hospital.

ADDED OPTIONS

The basic station is as described above. Following are equipment options that can be added to the basic equipment to meet additional service needs.

I. Additional Receive Channels

Additional receive only channels may be added to provide radio distribution or to provide continuous monitoring of the health service channel when the regular receiver is not available.

II. Added Transmit and Receive Channels

Additional transmit-receive equipment, similar to that of the basic station, may be added. This is to be used only in conjunction with larger receive stations or with a later satellite.

III. Direct Dial Telephone

A direct dial telephone may be added to the station to provide automated metered telephone service to the village. The added equipment includes a telephone, a supervisory unit, and an interface card to connect the supervisory unit to the digitally controlled transmitter and receiver of the station. This may be added along with a separate transmitter-receiver channel to the "Basic" station. Or it may be added in a way to share the transmitter-receiver of the "Basic" station.

SYSTEM OPTIONS

With the station options described above several system configurations are available. These are described below:

I. Basic Option, Health Service Only

The basic option has identical service at each location. All villages and the field hospitals are on a common push-to-talk circuit. If added channels are required for the traffic, different service areas can use different channels. In this configuration each village would be able to hear conversations only in its service area; but a station at a field hospital could be switched to any one of the service areas.

II. Shared Telephone Service

Adding the shared telephone package to the "Basic" station will provide direct dial telephone service to each location. The calls will go through a larger central station at Anchorage or Fairbanks and be routed through the normal telephone system. The central station equipment would be fully automated, including automatic billing.

In this configuration, for calls from one village to another, the central office equipment will establish a direct "one-hop" circuit. The only "two-hop" circuits that would occur would be calls that the Alaska network normally handles via satellite, e.g., Alaska to the lower 48 states.

The telephone service would have to be interrupted for health service use. Priority could be established either way between the two uses but it is assumed that normally the health services use would have precedence. By adding a receive only channel for the health aide to use for the normal daily conferencing, interruption would occur only when the aide participated in the conference to transmit messages, about 10 minutes per day. Other telephone calls could take place while the health aide was merely listening.

III. Separate Telephone Service

Adding the telephone and an additional transmit-receive channel to the "Basic" station will also provide direct dial telephone service to each location. Due to transmitter power limitations, in this configuration all calls would have to go through the larger central station.

A village-to-village call would incur a "double hop". Similarly, the simplex health service line would have to have a "double hop". The effect of this added delay on the conversations is not known. There would in addition to this difficulty, be extra costs due to the use of twice as many satellite channels.

In this case there would be no interruption of telephone service for health communications.

IV. Mixed Telephone Service

It should be noted that the three configurations described above can be used simultaneously; i.e., stations with health service only or with shared or separate telephone service work in the same system.

V. Central Telephone Equipment

The central telephone equipment for the direct dial service would consist of a control terminal and a connection to a larger multi-channel satellite station. Cost estimates are preliminary but indications are that the central terminal and channel equipment would cost from $100,000 to $120,000. If the larger ground was located near the telephone control terminal and served exclusively for the telephone service the satellite ground station cost would be less than $50,000. The total central station cost including dedicated ground station should cost between $150,000 and $170,000. Alternately, the present RCA stations could be used. It is not clear whether the rental of lines from a present RCA station and a share of the station cost would be less expensive than a new station.

The central telephone equipment and the telephone to be added to the stations in the villages are based on Motorola's Improved Mobile Telephone Service (IMTS) equipment. Their Pulsar central terminal equipment contains automated dialing, billing and revertive (mobile to mobile) call capability. The remote IMTS telephone equipment will simply interface with the basic ground station design. The central station equipment costs from $80,000 to $120,000 depending on the options. The remote telephone equipment would cost about $800. (Only the handset and supervisory unit would be used with the satellite ground stations.)

ATTACHMENT XI.9

ALASKA'S COMMUNICATION NEEDS AND POTENTIAL SOLUTIONS UTILIZING SATELLITES

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HEW/OTP

This is a preliminary staff study paper written for consideration by the Joint Committee on Telecommunications and other interested parties. It is incomplete, and represents a first draft of what should eventually be a much more comprehensive and detailed study. The final report will benefit from the comments of the committee and others and will then be suitable as an input into official DHEW Telecommunications policy.

Background

Alaskan native populations are probably the most isolated, poorly served, and educationally and medically disadvantaged of American citizens. The State's geography, population patterns, and harsh climate are largely to blame for this. People live in primitive villages, typically of a few dozen to a few hundred in population. Transportation is poor at best, and almost non-existent much of the year. Communications is made highly expensive and unreliable by geographical and atmospheric conditions. Particularly serious needs are for emergency medical communications, health aide--physician consultation in routine health maintenance and treatment, educational programming from pre-school to professional level, cultural and informational radio and TV service, and ordinary telephone communications. There is wide-spread agreement that the most viable and cost-effective solution to many of these problems is telecommunications, in particular communications satellites.

Beyond this general agreement, however, lies extensive disagreement on ways and means of providing such services. The disagreement is genuine and is based on a complex of interactive technical, financial, regulatory, and other factors. This is further compounded by uncertainties about near-term technical developments, intents of interested actors, future policy decisions and other factors. In spite of these real difficulties, decisions must be made immediately if any service is to be provided within the next year or two. One of these decisions involves DHEW's role in influencing and utilizing the satellite telecommunications in Alaska.

Alaska needs clearly are broader than DHEW's areas of responsibility. A telephone system serves countless purposes and television service will serve entertainment and informational needs as well as educational, health and social services. However, it is clear that only by sharing whatever facilities are planned can the various needs be met at a feasible and cost-effective price. Within the constraints of limited funds and small community size, only one telephone system and one television system is practical. Thus, DHEW, if it is to play any role, must participate in the overall system design to assure that its responsibilities and interests will be adequately served at the minimum cost compatible with satisfactory service.

Alternative Solutions

The best solution to Alaska's communications needs is, at the moment, difficult, if not impossible, to determine. One reason for this is the large number of unknowns and uncertainties facing the decision maker. One of the major causes for uncertainty is the lack of reliable technical and cost data on which to base analysis. There is only one way to clarify this issue and that is to enter a competitive market situation where service and hardware suppliers bid and negotiate service, product, terms, and prices. This implies that Alaska must consider a variety of alternative approaches to filling its telecommunications needs. Attempting, at considerable risk, to organize and simplify what is a very complex situation, we can describe three major approaches (with minor variations on each) to a sateilite telecommunications system for Alaska. These group themselves around three operating frequencies: 2.5/X, 4/6 and 12/14 GHz.

The 2.5/X system: This is the same frequency band as is to be used with the ATS-F. A satellite (the ATS-F') of the same type as the ATS-F could probably be launched within a year and could serve the existing (18) stations in Alaska. Additional stations could be added at low cost ($5000 ea) at the villages not now served by the ATS-F. This satellite, which is already partially built, has a beam pattern (earth coverage) which could adequately serve most of Alaska with excellent TV and telephone service and simultaneously provide interconnects with points in the northwest continental U.S. The technology may be considered moderately well developed, and will be fully tested within the year. Such a satellite would essentially be an extension of the ATS-F project, possibly using more sites, more and different services, and possibly greater efficiency, as it could dedicate its entire capacity, 24 hours/day, to service Alaska. Another possibility is the sharing of its use with the other ATS-F HET participants in the Rocky Mountains and Appalachia. However, this would not permit 24 hour/day emergency telephone communications in Alaska.

The original ATS-F satellite may well have a life span of several years and be able, once it completes its year serving India, to return and serve Alaska and/or the other U.S. participants. This would still leave a gap of one year in the U.S. service. This gap could be filled (if the F' could be launched on time) and result in a several year period where two satellites were available to service Alaska, the Rocky Mountains, and Appalachia, or even other experimenters. At the end of the somewhat unpredictable life span of the F and F' satellites, a new satellite could be launched to continue the service.

The main disadvantage of the 2.5/X GHz system is the cost of the satellite in order to serve a region as "small" as Alaska. At this frequency a large satellite antenna is required. This is itself expensive and requires a large and expensive launch vehicle. Overall the cost could be about three times the cost of alternative systems and would make the cost of a "back-up" (in case of failure) satellite in orbit, or even on the ground, of questionable feasibility. To avoid this problem a 2.5 GHz satellite with a small antenna could be purchased for far less cost. This would cover the entire U.S., plus Alaska, but in so doing would dissipate much of its power over the large area so that a much lower (perhaps even marginal) quality TV would be possible. There would be a distinct advantage in this nationwide coverage option in that TV programming, a critical factor, could be mutually shared among all participating states. This would bring more high-quality general purpose educational programming to Alaska, but would limit service of Alaska's unique needs. Such a scheme is also dependent on the simultaneous development of a social service satellite project on a nationwide basis and is thus organizationally, politically, and administratively more complex and problematic.

The system is called the 2.5/X because it is not known what uplink frequency (X) would be used. The present ATS-F uses the 2.25 GHz band for uplink, but is doing so only on a temporary and conditional license since this frequency use on uplink may interfere with other important uses. It is improbable that continued use and/or an expanded number of sites in Alaska or elsewhere would be regulatorily possible. If not, then another frequency (e.g., 6 GHz) would have to be used. This brings up problems which will be discussed in the 4/6 GHz system.

The 4/6 System: This is the standard commercial system. An existing Canadian satellite (Anik), a U.S. satellite (Westar) and another proposed U.S. satellite (by RCA) are possible service providers. Thus, satellite capacity exists today and is highly developed. Basic telephone service may be possible with relatively inexpensive terminals ($20,000). Such a technology has been experimentally developed and demonstrated. Provision of TV over such inexpensive stations and using standard communications satellites is highly questionable. Most probably TV would require larger and considerably more expensive ground stations. The fact that the satellite capacity exists and will increase removes the immediate capitalization problem for Alaska whose cash flow will be large a few years from now, but is presently minimal. Also, the general purpose nature of the satellite capacity means that Alaska need only pay for whatever use is required at any time. This system offers potential immediate service and is the only one to do so. In practice this may be of less importance since the bidding, selections, manufacturing and installation process make any real service offering in much less than one-year almost impossible.

Television service using expensive ground terminals will probably be prohibitively expensive for most villages. Thus, a major need and goal of Alaska will not be met. Raising satellite power to make it compatible with less expensive ground stations may be expensive due to lack of established hardware at the frequency. Also it is questionable whether regulatory considerations (FCC) will permit either high-power satellite transmissions which might interfere with ground or other satellite service in this heavily used commercial frequency or small earth stations which might scatter upward transmissions over large areas of precious orbital space. The terminals, though "inexpensive" relative to commercial installations, are still more expensive than competing systems discussed here, mostly because there are limits imposed on satellite power, uplink power, and antenna size, not by the technology per se, but by the heavy use of this frequency band.

The 12/14 System: This high frequency band is lightly used at present. Therefore, very high power satellites may be used in conjunction with quite small low-cost earth stations. Present estimates of receiving TV earth station cost are about $1500 within a year or two and eventually in the hundreds of dollars range. Local ground transmitters can be made cheaper than at other frequencies, because of the very low output power requirements. Also they consume much less electrical power - an important consideration in the bush. The high frequency makes small antennas possible, both in the satellite and on the ground. Thus, all elements of the system can be made inexpensive. Furthermore, it is possible at this frequency to cover efficiently almost any specified area (e.g., Alaska) with beam shaping, thus minimizing wasted energy transmission. There is enormous bandwidth capacity, so that all Alaska's communications needs for the foreseeable future could be handled. Clearly, there are many technical reasons which point to the conclusion that the 12/14 system might ultimately be the system of choice for intra-Alaska communications.

The greatest disadvantage of the 12/14 system is that it is a new technology and the least well developed of the systems discussed. The high power transmitter tube has been developed and tested for the CTS (Communications Technology Satellite), a Canadian/U.S. joint endeavor scheduled for launch in 1975. However, this tube (a traveling wave tube) has not been proven in satellite service. The low-cost ground stations are under development in Japan, but are not yet available, tested, or proven; nor has their cost been established, in fact. This is a higher risk alternative and may take a year or so longer to implement than other systems.

The fact that 12/14 is suited for accurate beam coverage of Alaska, while making the system an efficient special purpose communications system, limits its utility for covering other areas such as the lower 48 or a portion thereof. This implies that the entire system (e.g., two TV channels and several voice and radio channels) would be dedicated to and charged to Alaska. The State would be "stuck with" the full expense and thus forced to rapidly develop the programming, organization, service, etc., required for a full-time telecommunications system. This would involve considerable expense in money, talent, and other resources. Obviously, this system requires considerable organizational and regulatory consideration.

A basically intra-Alaska system would not solve the external communications needs of the State. There are two solutions to that problem. A spot beam from the satellite could be directed at a major communications center in the lower 48 and there interconnect with the international and national system; or one or a few commercial stations, located in Alaska's major cities and operating with the commercial domestic satellite system, could provide the interconnect. In either case, both bush and interstate traffic would be covered.

Some early (1976) experimentation would be possible at 12/14 using the CTS system. If a decision had already been reached to use that frequency, the CTS would enable an early beginning of some sort of service. If the decision were put off, awaiting results of the CTS experiments, the complete system would be substantially delayed.

The Hybrid System: There is no basic reason why both voice and TV traffic must be accomplished on the same frequency band. It is possible to operate, say, the telephone system at 4/6 and the television broadcasting at 2.5 or 12. There are difficulties with dual-frequency antenna feeds which would incur additional expense and possibly performance degradation. It is also possible to operate with more than one antenna, if this proves cheaper or otherwise more desirable. While the inherent disadvantages of such hybrid operation are obvious, there could be practical advantages to the overall system which would make it most cost-effective. Such a technical possibility deserves consideration and should not be excluded from alternatives to be considered.

The Timing Problem and Interim Solutions

While complete certainty of information will never be achieved, it seems premature to proceed with a system choice without knowing the actual alternatives, costs, and timing which the market will offer. It follows that some delay is necessary before a choice is made. Adding this to lead times required for specification, bidding, evaluating bids, construction, installation, etc., it is clear that the overall system will not be achievable for 2-3 years. Meanwhile, the need, most dramatically for emergency communications, but also importantly for educational, informational and personal communications, exists right now. What limited service ATS-1 has offered has had dramatic results in medical treatment. Unfortunately, that satellite has outlived its time and may cease operating any day. Many communities have come to depend upon it and radio communications, never very satisfactory, have fallen into disuse where the ATS-1 serves.

It is possible, and perhaps within a year or less, to initiate 24-hour telephone service using existing commercial satellites and fairly low-cost earth stations ($20,000 ea for 2-way terminals). These could provide minimum interim service of voice only or equivalent fax, data, computer feed, slow scan TV, etc., until the final system was chosen, acquired and operating. The problem with this approach is that some portion of the equipment may become immediately obsolete when the final system begins operation, that is assuming the final system operates at a different frequency than does the interim. The cost of the obsoleted (not wasted actually, but rather amortised over a shorter interim life-span) portion of the equipment can be minimized by proper specification of "convertible" equipment in selecting interim hardware. There is reason to believe, but no certainty, that the majority of the terminal equipment, in cost terms, would be usable at any of three frequency bands discussed here (as well as others if appropriate). Such "convertable" equipment, if manufacturers can actually deliver it to specifications, could reduce considerably the cost of interim service. This situation is being investigated in connection with an Indian Health Service project (see Tab A - a memo on the subject).

The Carrier Problem

It is one thing to select a technology that offers the best service; there must also be an entity which will make that technology and that service available. That entity must meet the requirements of and be authorized by the FCC. Some satellite and equipment manufacturing companies may not choose or be able to operate as a communications carrier so it would be necessary to find or create such an entity. This process would additionally complicate and possibly delay the development of a satellite communication service. The possibility of Alaska forming a public communications utility also arises. This would require both substantial funds and professional talent.

Tentative Conclusions and Recommendations

1. DHEW's interests are congruent with Alaska's overall interests in seeing that an adequate telecommunications system exists to serve their needs.

2. An integrated system serving all users is the most cost-effective approach.

3. A final decision on the ultimate system cannot be made until realistic information on availabilities, costs, and timing are available.

4. Competitive bidding is the best and perhaps only way to obtain the above information.

5. DHEW should take the necessary steps to encourage a competitive bidding situation.

6. An interim system should be considered as the only way to satisfy short-term Alaskan needs. A variety of users may wish to participate.

7. Any interim system will be experimental and should be of limited extent, at least until the technology and operating system are proven.

8. Any interim system must be implemented so as to be convertible at minimum cost to alternate frequencies.

9. DHEW should provide continuing technical, analysis, and liaison support to the Alaskan telecommunications project for two reasons:

a. To assure that any Alaskan telecommunication system meets the health, education, and other social service needs of the people of Alaska in fulfillment of DHEW's relevant responsibilities.

b. So that the technological and service experiments and experience can yield benefits to other potential users, including statewide, regional, or national social service systems.

ATTACHMENT XI.10

Review of RCA Small Station Request for Proposal

RCA Alascom has issued a request for proposals to equipment manufacturers for small earth stations (RCA Alaska Communications, Inc., 1974). Following are analyses of some of the major aspects of RCA's system design.

(A) Station Cost

A satellite ground station has four main components (see Fig. A). If a higher performance option is selected for one of the components, lower price, lower cost components can be used in the rest of the station. The combination selected by computer optimization (Attachment XI.4) was used in the Point Reyes station (Attachment XI.5) The way RCA's request for proposals (Reference 1) is worded does not allow this lowest cost system to be bid. This is best illustrated by comparing the components specified by RCA with the performance actually needed to provide the required communications.

The channel equipment specifications (Reference 1, page 30) allows two approaches to be used, FM or Delta Modulation. However, the California Microwave System, used by General Telephone and Electric in satellite stations in Brazil and Algeria, would not meet the FM specifications the way they are stated.

This optimum FM equipment costs the same or somewhat less than the Delta Modulation equipment RCA specifies. Its main advantage is that it can provide toll quality telephone service with a signal that is five time weaker than that needed for the Delta Modulation or other FM systems. This performance allows major reductions in performance and cost of the

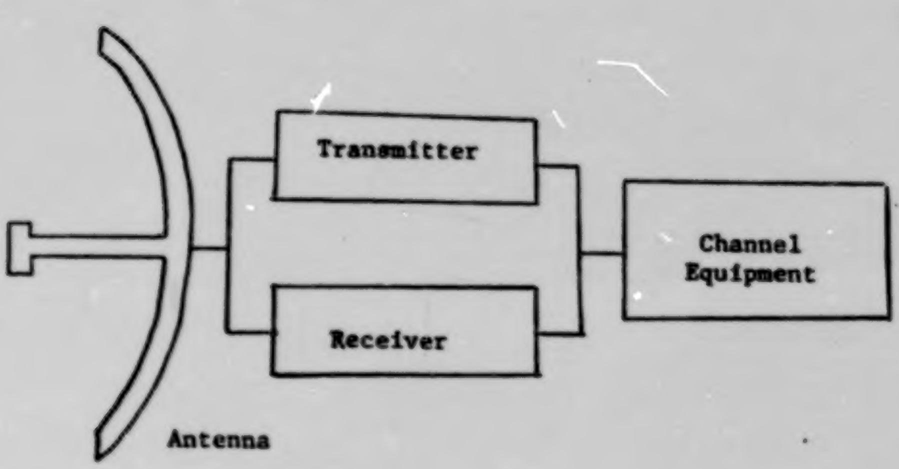


Figure A: Satellite Ground Station

other station components. But RCA's specifications do not reflect this possibility.

RCA has proposed communications only through the large stations in Lena Point or Talkeetna (Reference 1, page 1-3). Though this presents a serious time delay (Section C), we will accept it for the moment and contrast the specifications actually required for the optimum FM system with those RCA requires in their request for proposals.

The transmitter that is suitable for this service to large stations actually requires output power of only one watt; RCA's specification (Reference 1, page 3-17) calls for a 100 watt transmitter. Not only is the transmitter far more expensive than needed, but the electric power required from the village supply will be much more.

The Preamplifier that is suitable for this service can have a noise temperature of 520°K; RCA's specification calls for a more sensitive Preamplifier with a smaller noise temperature of 300°K (Reference 1, page 3-25)

This specification is not only more stringent, but it does not correspond to a standard component. Inexpensive transistor amplifiers are available in the 520°K range. Very expensive parametric amplifiers are available at 100°K or better. But none exist in between.

The FCC's concern with satellite interference with this antenna is discussed below (Section B). In addition, the FCC specification provides for protection of nearby ground systems. To meet this specification would add about 80% of the antenna cost (Attachment XI.5). The FCC allows for local coordination in lieu of meeting the specification, but RCA requires this antenna protection (and the extra cost) even though there are no systems in the vicinity of the small stations to be interferred with.

The parameters discussed above are the key ones that determine the station cost. RCA specifications are not discrepant by small amounts that can cause small cost differences but are discrepant by very large amounts on all station components. A station bid to the RCA specifications will cost two or three times as much as the lowest cost alternative.

(B) Antenna Interference

There has been a question from the start whether the Federal Communications Commission would allow satellite stations with 10 ft. antennas. It was originally thought that the FCC would require antennas 30 ft. or greater. If this were done, it would virtually preclude satellites from being used for Alaskan rural communications; such antennas would add well over $100,000 to the station cost, putting them economically out of reach of small villages.

The FCC's concern is that signals transmitted to one satellite in synchronous orbit may interfere with another satellite nearby. Stanford and others (FCC 73-314, Docket No. 19495) urged that the FCC provide protection by specifying the electrical characteristics of the antenna rather than by an arbitrary limitation of antenna size. This would allow antenna manufacturers to satisfy the FCC's concerns with properly designed low-cost antennas. The FCC accepted this approach and adopted the performance pattern shown in Fig. B.

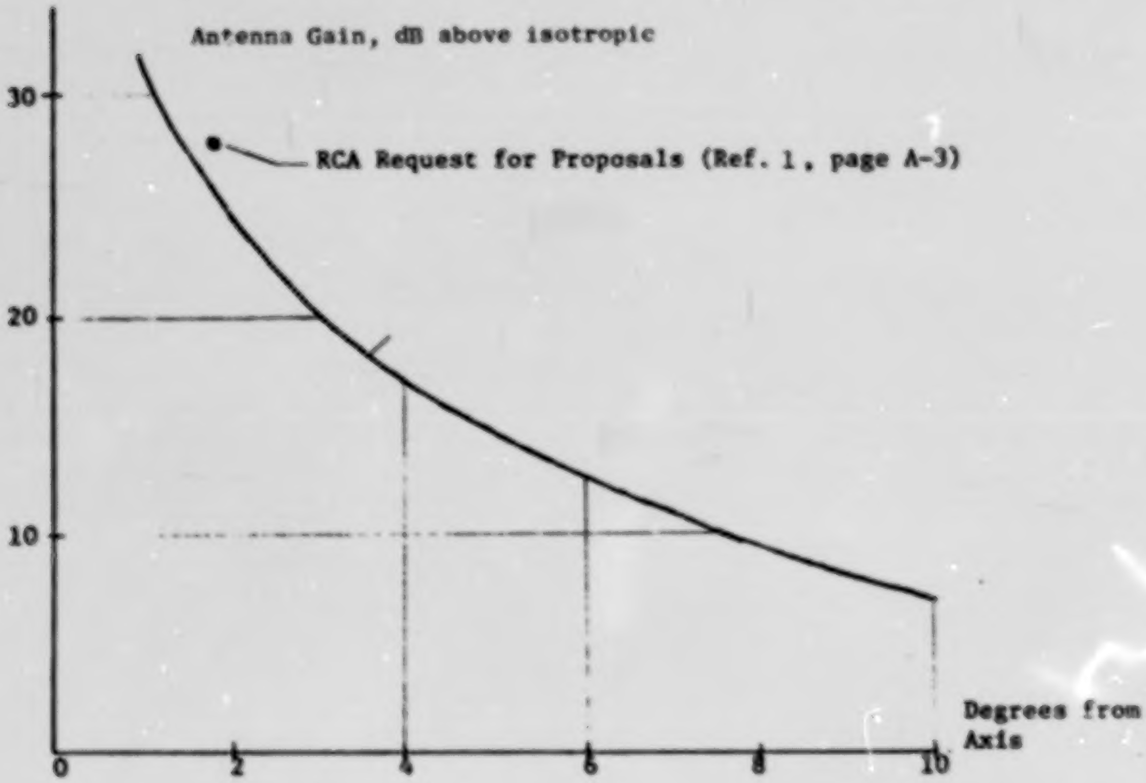


Figure B. Antenna Sidelobe Performance

The 10 ft. antenna demonstrated at Point Reyes met the FCC specification for protection of adjacent satellites (Attachment XI.5) and this was demonstrated as part of the test program.

The low-cost stations, while meeting Alaska's communications needs, would also introduce vigorous (and not very welcome) competition to the communications industry. It is, therefore, extremely important that the stations meet the FCC specifications and avoid any excuse for a protest on technical grounds.

The request for proposals (Reference 1, page 3-12), in the first sentence requires the FCC specification to be met; but in the next sentence, allows a performance that clearly violates the FCC regulation by about 4 dB (See Fig. B).

The way the station is specified greatly increases the chances that it would be challenged and perhaps turned down for non-conformance to the FCC regulations.

(C) Satellite Time Delay

Communications satellites are located about 22,000 miles above the equator. Radio signals make the trip up to the satellite and back in about 1/3 second. The time for a comment to travel from the caller through the satellite to the listener and the response to travel back through the satellite to the caller is twice as long, about 2/3 second. This 2/3 second response delay is noticeably on satellite calls to the lower 48 states, but is quickly adapted to in normal conversations.

Because the RCA small stations are specified to communicate only through the large Lena Point or Talkeetna earth stations (Reference 1, page 1-3), a call from one small earth station to another small earth station must travel through the satellite twice. A comment travels from the caller through the satellite to Talkeetna, back out through the satellite again to the listener, and the response similarly goes twice through the satellite on its way back to the caller. The response delay is about 1 1/4 seconds.

This long delay is much more noticeable and bothersome to conversations. (The delay is about half as long as the delay encountered by the astronauts when they were on the moon.) The delay is sufficiently disturbing that AT&T will not accept phone calls with two satellite hops; thus, if Bethel communicates to Lena Point via satellites, calls to the lower 48 states have to be routed via land lines to avoid a second satellite link.

Most of the communications needed by the Alaska Area Native Health Service would have to have two hops under such a system. For this reason, the optimum station demonstrated at Point Reyes was designed to communicate with another of the same size (Attachment XI.5) avoiding the double hop. This requires a transmitter of 30 watts rather than the one watt to transmit to the large stations (Section A). This 30 watt transmitter is still far less expensive than the 100 watt transmitter RCA specified.

Thus two hop service is not acceptable to communicators and it is possible to avoid it with proper system design.

(D) Microwave Hazard

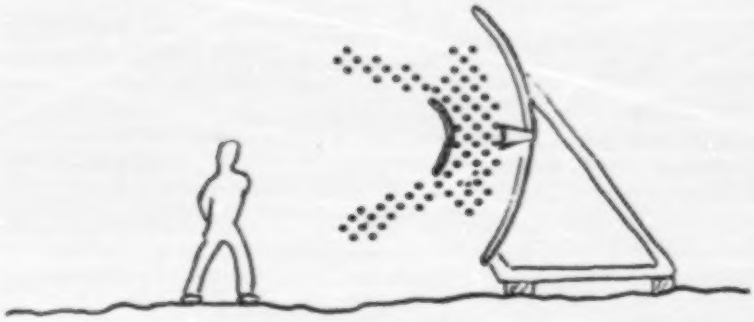
Microwave radiation is obviously a very sensitive area that should be treated with care. The concern is that the microwave energy transmitted from the antenna may have power levels high enough to constitute a health hazard.

The radiation limit set by the Occupational Safety and Health Act of 1970 is 10 mW/cm^2. Calculations indicate that with a normal antenna and a 50 watt transmitter this level is exceeded only in an area within the antenna volume near the feed (See Fig. C-a). This area is easy enough to protect people from simply by using the antenna structure to prevent easy access.

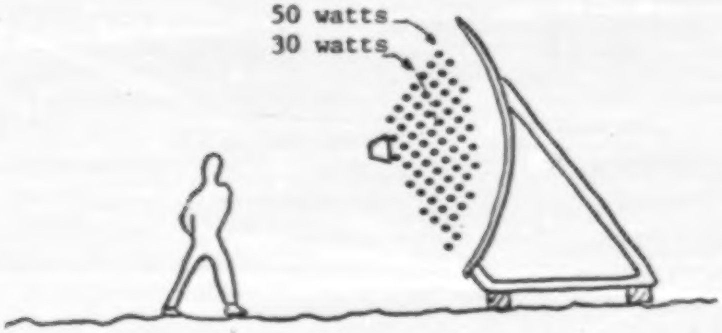
However, RCA neglects to consider that with the Cassegrain antenna type they have allowed in their request for proposals, there is a danger zone in front of the antenna. This is where energy from the Feed Horn spills around the Sub-Reflector (See Fig. C-a). It is hard to protect people from this radiation since it extends in front of the antenna structure for about 10 ft. and is near the ground. This presents another point on which the FCC could reject the application.

The problem is readily rectified by using the alternative antenna type (Newtonian) as was used in the Point Reyes station. With this design the energy is directed initially back toward the antenna and the high radiation is all within the antenna volume (Fig. C-b). In this figure, the danger zone is shown for a 50 watt transmitter and for 30 watts as required in the optimum configuration. Figure C-d shows the area for 5 watts, which is the amount required for 5 circuits in the future, if RCA's satellite carries the proper transponder gain (See Section E).

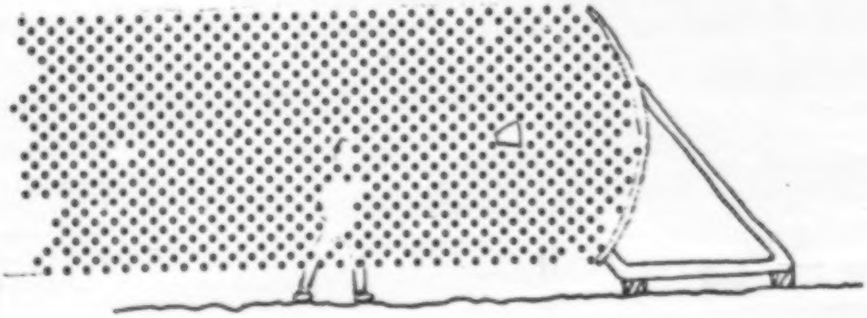
The serious long-range worry is that RCA will not modify their satellite transponder gain. In this event, future expansion of the system with multiple channels and with direct communications between



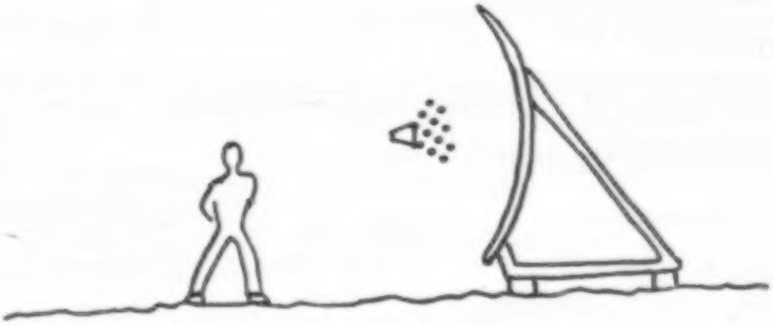
a. Hazardous area with 50 watts and Cassagrain Feed.



b. Hazardous area with 30 and 50 watts and Newtonian Feed.



c. Hazardous area with over 180 watts.



d. Hazardous area with 5 watts and Newtonian Feed.

Figure C. Microwave Radiation Hazard Areas small stations will require far more power than the 50 watts of RCA's present proposals. It will require at least 150 watts if they chose the optimum modulation, 750 if they use the Delta Modulation system. To generate this power, with the inefficiencies of multi-channel transmitters, will require transmitters capable of 600 to 3,000 watts.

The RCA request for quotations specifies 100 watts (Reference 1, page 3-17). RCA also requires that the equipment be easily upgraded to 300 watts (Reference 1, page 3-22). And the antenna is required to be usable to a power of 3,000 watts (Reference 1, page 12).

A power level of only 180 watts creates a hazardous microwave radiation level in the near field of the antenna (See Fig. C-c). Because, for Alaska, the satellite is very low in the sky, this beam shines almost directly towards the horizon. To protect people from this hazard, the antenna would have to be mounted on a tower or hill, incurring significant additional expense. RCA makes no mention of such precautions in their documents.

If the satellite transponder gain is set properly (Section E), the transmitter level required would be only 5 watts and the hazardous area would be restricted to a small area within the antenna (Fig. C-d).

(E) RCA Satellite Transponder Gain

The satellite transponder gain determines what strength signal from the ground is needed to get the desired power out of the satellite. The best setting for the transponder gain is heavily dependent on the size of the ground stations using the satellite. The Anik satellite has been set optimally for communication between large ground stations suitable for trunk lines between major cities. Similarly, RCA's present satellite design calls for a transponder gain setting appropriate for communication between San Francisco and New York or between such cities and Alaska.

The importance of the correct value of transponder gain in satellite systems design is illustrated by the two sets of link calculations shown. below. The set on the left is based on the current Anik satellite transponder gain of 114.9 dB/dB/m^2. Notice that for this gain the up-link C/kT is 23.9 dB "cleaner" than the down-link C/kT (i.e., the down-link is almost 250 times noisier than the up-link).

There is, obviously, no need for such a clean up-link, especially since it has to come at the expense of a much larger than optimal up-link power requirement and would not be needed with a proper setting of the transponder gain. (It may be helpful in considering this unbalance in C/kT to remember that when combining two C/kT ratios differing by 6 dB, the total will be only 1 dB below the smaller of the two.) A dramatic reduction in up-link power is possible merely by increasing the gain of the transponder. In terms of baseband noise contributions, an increase in the transponder gain would permit a large increase in the noise contributed by the up-link and require a very slight decrease in that contributed by the down-link, thus narrowing the difference between up-link and down-link C/kT.

For the sake of illustration, the set of link calculations on the right assumes a new value of transponder gain equal to 133 dB/dB/m^2. The same overall C/kT is achieved, yet the up-link power per channel has been cut from 30 watts to less than 0.6 watts.

LINK PARAMETERS

Up-Link Frequency	6.0 GHz
Path Length to Satellite	41173.0 km
Down-Link Frequency	4.0 GHz
Satellite G/T -- On Axis	-7.0 dB/Deg K
Satellite Intermod Relative to EIRP	-15.0 dB

LINK CALCULATIONS

Transmitter Power	14.8 dB	-2.3 dB
Station Antenna Diameter	10 ft	10 ft
Transmit Gain	43.0 dB	43.0 dB
Transmit Line Loss	1.5 dB	1.5 dB
Flux at Satellite	-107.0 dB	-124.1 dB
C/kT Up	74.6 dB-Hz	57.7 dB-Hz
Satellite Transponder Gain	114.9 dB/dB/m^2	133.0 dB/dB/m^2
EIRP from Satellite	7.9 dB	8.9 dB
Receive Line Loss	0.8 dB	0.8 dB
Preamplifier Noise (TDA, 4.5 dB NF)	525.0 Deg K	525.0 Deg K
System Noise Temperature	570.0 Deg K	570.0 Deg K
Receive Gain	39.5 dB	39.5 dB
Receive G/T	11.6 dB	11.6 dB
C/kT Down	50.7 dB-Hz	51.7 dB-Hz
RF Bandwidth	20.0 kHz	20.0 kHz
C/IM Noise Density	58.0 dB-Hz	58.0 dB-Hz
C/kT Total	50.0 dB-Hz	50.0 dB-Hz

Since Anik is already in orbit, the penalty on the ground stations must be accepted in the first phase. The 30 watt transmitter (14.8 dB) in the ground station is what is needed for small station-to-small-station communications. With the proper gain in RCA's satellite, less than one watt (-2.3 dB) would be adequate.

Looking to the future, additional circuits are anticipated in the small ground stations. If 5 circuits are needed, a 600 watt transmitter would be required with the present RCA satellite design. (This increase accounts for reduction in efficiency when several circuits are run through the same transmitter.) This would make a major impact on the station cost and demand on local electric power. If RCA elects to use the less efficient Delta Modulation channel equipment, 5 channels would require a 3,000 watt transmitter, a very sophisticated and expensive system to put into a small village.

The satellite transponder gain can be set to greatly reduce this problem. With the proper setting, 5 channels can easily be transmitted through the 30 watt transmitter.

The RCA satellite will carry 24 transponders, all currently planned to be set for big city communications. If the satellite is to serve Alaska, it would seem appropriate to have at least one or two of the transponders set to meet Alaska's rural communications needs.

Reference

1. RCA Alaska Communication, Inc., Request for Proposal for the Design and Manufacture of Small Aperture Earth Stations, July, 1974.